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Development Document for Proposed Effluent Limitations Guidelines & New Source Performance Standards for the Organic Chemicals & Plastics & Synthetic Fibers Industry, Point Source Category Volume 1. (BPT) (Best Practicable Technology)

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Point Source Category
Volume I (BPT)

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16. ABSTRACT

This document presents the findings of studies of the organic chemicals and plastics and synthetic fibers manufacturing point source category for the purpose of developing effluent limitations guidelines for existing point sources. Effluent limitations guidelines proposed herein are for "best practicable technology", "best conventional technology", and "best available technology", new source performance standards and pretreatment standards as required under Sections 301, 304, 306, 307, and 501 of the Clean Water Act (the Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. 1251 et seq., as amended by the Clean Water Act of 1977, P.L. 95-217 (the "Act")), and as required under the Settlement Agreement in Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified 12 ERC 1833 (D.D.C. 1979), and modified again by order of the court dated October 26, 1982.

This document contains the supporting data and rationale for development of the effluent limitations and guidelines including subcategorization schemes, wastewater characteristics, treatment technologies and costs.

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DEVELOPMENT DOCUMENT
for

PROPOSED EFFLUENT LIMITATIONS GUIDELINES
AND
NEW SOURCE PERFORMANCE STANDARDS

FOR THE

ORGANIC CHEMICALS AND PLASTICS AND SYNTHETIC FIBERS INDUSTRY

VOLUME I

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NOTICE

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On February 28, 1983, EPA proposed effluent limitations guidelines and standards for the organic chemicals and plastics and synthetic fibers (OCPSF) point source category. The Federal Register notice of this proposal was printed on March 21, 1983 (48 FR 11828 to 11867).

Information received by the Agency after proposal indicates that the total OCPSF industry estimated annual discharges of toxic pollutants are too high. The Agency will be reevaluating these estimates when additional information becomes available prior to promulgation of a final regulation. In the interim, the Agency advises that there should be no reliance on the annual total toxic pollutant discharge estimates presented in the Federal Register notice, the February 1983 OCPSF Development Document, and February 10, 1983 OCPSF Regulatory Impact Analysis.

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SECTION I

INTRODUCTION

PURPOSE AND LEGAL AUTHORITY

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to restore and maintain the chemical, physical and biological integrity of the nation's waters [Section 101(a)]. by July 1, 1977 existing industrial direct dischargers were required to achieve effluent limitations requiring the application of the best practicable control technology currently available (BPT) [Section 301(b)(1)(A)]. By July 1, 1983 these dischargers were required to achieve effluent limitations requiring the application of the best available technology economically achievable (BAT), which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants [Section 301(b)(2)(A)]. New industrial direct dischargers were required to comply with Section 306 new source performance standards (NSPS) based on best available demonstrated technology. New and existing dischargers to publicly owned treatment works (POTW) were subject to pretreatment standards under Sections 307(b) and (c) of the Act. The requirements for direct dischargers were to be incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402 of the Act. Pretreatment standards were made enforceable directly against dischargers to POTWs (indirect dischargers).

Although Section 402(a)(1) of the 1972 Act authorized local authorities to set requirements for direct dischargers on a case-by-case basis, Congress intended that for the most part control requirements would be based on regulations promulgated by the EPA Administrator. Section 304(b) of the Act required the Administrator to promulgate regulatory guidelines for direct discharger effluent limitations, setting forth the degree of effluent reduction attainable through the application of best practicable control technology (BPT). Moreover, Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS, and Sections 304(f), 307(b) and 307(c) required promulgation of regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307 (a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 501(a) of the Act authorized the Aministrator to prescribe any additional regulations necessary to carry out his or her functions under the Act.

The EPA was unable to promulgate many of these regulations by the dates contained in the Act. In 1976 EPA was sued by several environmental groups. In settlement of this lawsuit, EPA and the plaintiffs executed a settlement agreement which was approved by the Court. This agreement required EPA to develop a program and adhere to a schedule for promulgating, for 21 major industries, BAT effluent limitations guidelines, pretreatment standards and new source performance standards for 65 "toxic" pollutants and classes of pollutants.

On December 27, 1977 the President signed into law the Clean Water Act of 1977. Although this law makes several important changes in the federal water pollution control program, its most significant feature is its incorporating into the Act several of the basic elements of the settlement agreement program for toxic pollution control. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act now require the achievement by July 1, 1984 of effluent limitations requiring application of BAT for toxic pollutants, including the 65 priority pollutants and classes of pollutants which Congress declared toxic under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant controls. Moreover, to strengthen the toxics control program, Congress added Section 304(e) to the Act, authorizing the Administrator to prescribe best management practices (BMPs) to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revised the control program for "conventional" pollutants (including biochemical oxygen demand, suspended solids, fecal coliform, oil and grease, and pH) identified under Section 304(a)(4). Instead of BAT for conventional pollutants, the new Section 301(b)(2)(E) requires by July 1, 1984 achievement of effluent limitations requiring the application of the best conventional pollutant control technology (BCT). The factors considered in assessing BCT include the reasonableness of the relationship between the costs of attaining a reduction in effluents and the effluent reduction benefits derived, and the comparison of the cost and level of reduction for an industrial discharge with the cost and level of reduction of similar parameters for a typical POTW [Section 304(b)(4)(B)]. For nontoxic, nonconventional pollutants, Sections 301(b)(2)(A) and 301(b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment or after July 1, 1984 (whichever is later), but not later than July 1, 1897.

This document presents the technical bases for the application of revised BPT, BCT and conventional pollutant new source performance standards (NSPS) for the organic chemicals and plastics and synthetics (OCPS) manufacturing point source category. The technical bases for toxic pollutant related limitations are presented in the "BAT" Development Document which is being published jointly with this report.

PRIOR EPA REGULATIONS

EPA promulgated effluent limitation guidelines and standards for the Organic Chemicals Manufacturing Industry, in two phases, in 40 CFR Part 414. Phase I, covering 40 product/processes (a product that is manufactured by the use of a particular process--some products may be produced by any of several processes), was promulgated on April 25, 1974 (39 FR 12076). Phase II, covering 27 additional product/processes, was promulgated on January 5, 1976 (41 FR 902).

EPA also promulgated effluent limitation guidelines and standards for the Plastics and Synthetics Industry, in two phases, in 40 CFR Part 416. Phase I, covering 31 product/processes, was promulgated on April 5, 1974 (39 FR 12502). Phase II, covering 8 additional product/processes, was promulgated on January 23, 1975 (40 FR 3718).

Several industry members challenged the above regulations. On February 10, 1976 the Court, in Union Carbide v. Train, 541 F.2d 1171 (4th Cir. 1976), granted the parties' motion to remand the Phase I Organic Chemicals regulations. The Court also directed EPA to withdraw the Phase II Organic Chemical regulations, which EPA did on April 1, 1976 (41 FR 13936). Pursuant to an agreement with the industry petitioners, however, the regulations for butadiene manufacture were left in place. The court in FMC Corp. v. Train, 539 F.2d 973 (4th Cir. 1976). remanded the Phase I Plastics and Synthetics regulations. In response, EPA withdrew both the Phase I and Phase II regulations on August 4, 1976 (41 FR 32587) except for the pH limitations, which had not been addressed in the lawsuit.

Today, there are no promulgated regulations for the Organic Chemicals and Plastics and Synthetics Industries, except for the butadiene and pH regulations mentioned above.

This report prsents a summary of the data collected by the studies undertaken since 1976, and the analyses used to support the proposed regulations. Section II presents a summary of the findings presented in this document, along with the proposed regulations. Sections III through VIII present the technical data and the supporting analyses used as the bases for the proposed regulations, and Sections IX through XI include the actual numerical development of the national limitations. Detailed data displays are included in Appendices A-G.

SECTION II

SUMMARY AND CONCLUSIONS

SUMMARY

EPA is proposing effluent limitations guidelines basd on the application of the best practicable technology (BPT), best conventional technology (BCT), best available technology (BAT), new source performance standards (NSPS) and pretreatment standards for existing and new sources (PSES and PSNS).

These proposed regulations apply to wastewater discharges resulting from the manufacture of organic chemicals, plastics and synthetic fibers. The organic chemicals industry is generally included within the U. S. Department of Commerce, Bureau of the Census Standard Industrial Classification (SIC) Major Groups 2865 and 2869. The plastic and synthetic fibers industry is generally included in SIC Groups 2821, 23823, and 2824. Due to the interdependence of these two industries, EPA studied them in combination and is including both of them in a single set of proposed regulations.

When finally promulgated, these regulations will supersede the existing regulations for butadiene manufacture and the pH limitation for the manufacture of plastics and synthetic fibers.

Some plants have OCPS operations that are a minor portion of and ancillary to their primary production. In some such cases, effluent guidelines for the primary production category (e.g., the guidelines for the petroleum refining, pesticides, and pharmaceuticals industries) include subcategories for the discharge of combined wastewaters from the primary production and the OCPS processes. In such cases, to avoid duplication and potential inconsistencies, these OCPS discharges are excluded from coverage by the proposed OCPS regulations and remain subject to the other applicable regulations.

The proposed regulations also do not apply to discharges from the extraction of organic chemical compounds from natural materials. Natural materials used to make organic chemical compounds include a variety of parts of plants (e.g., trees and seaweed) and animals. These proposed regulations address the manufacture of organic chemicals via chemical synthesis. Readers should note that extraction of chemical compounds from natural materials is included in many other industrial categories, e.g., Adhesives and Sealants, Pharmaceuticals, and Gum and Wood Chemicals. Readers should also note that discharges from the synthesis of organic chmical compounds that have been extracted from natural materials are covered by these proposed regulations.

The OCPS industry is large and diverse, and many plants in the industry are highly complex. The industry includes approximately 1,200 facilities which manufacture their principal or primary product or group of products under the OCPS SIC Groups. Some plants are secondary producers, with OCPS products ancillary to their primary manufacture. Various sources studied by EPA indicate that the number of secondary OCPS plants is in the range of

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320 to approximately 900 plants. Thus, the total number of plants in the OCPS industry may be as high as 2,100. This range is attributed to the difficulties inherent in segregating the OCPS industry from other chemical producing industries such as petroleum refining, inorganic chemicals, pharmaceuticals and pesticides as well as chemical formulations industries such as adhesives and sealants, paint and ink, and plastics molding and formulating. Even though over 25,000 different organic chemicals, plastics and synthetic fibers are manufactured, only 1,200 products are produced in excess of 1,000 pounds per year. As mentioned above, except for certain specified exceptions, all discharges from OCPS operations at these plants are covered by these proposed regulations.

Some plants produce chemicals in large volumes, while others produce only small volumes of "specialty" chemicals. Large-volume production tends toward continuous processes, while small-volume production tends toward batch processes. Continuous processes are generally more efficient than batch processes minimizing water use and optimizing the consumption of raw materials in the process.

Different products are made by varying the raw materials, chemical reaction conditions and the chemical engineering unit processes. The products being manufactured at a single large chemical plant can vary on a weekly or even daily basis. Thus, a single plant may simultaneously produce many different products in a variety of continuous and batch operations, and the product mix may change frequently.

Total production of organic chemicals in 1980 was 291 billion pounds, with sales of $54 billion. Production of plastics and synthetic fibers in 1980 was 60 billion pounds, with sales of $26 billion.

For the 1200 facilities whose principal production relates to the OCPS industry, approximately 40 percent are direct dischargers, approximately 36 percent are indirect dischargers (plants that discharge to publicly owned treatment works), and the remaining facilities use zero or alternative discharge methods. The estimated average daily flow per plant is 2.31 MGD (millions of gallons per day) for direct dischargers and 0.80 MGD for indirect dischargers. The remainder use dry processes, reuse their wastewater, or dispose of their wastewater by deep well injection, incineration, contract hauling, or evaporation or percolation ponds.

As a result of the wide variety and complexity of raw materials and processes used and of products manufactured in the OCPS industry, an exceptionally wide variety of pollutants are found in the wastewaters of this industry. This includes conventional pollutants (pH, BOD, TSS and oil and grease), toxic pollutants (both metals and organic compounds), and a large number of organic compounds produced by the industry for sale).

To control the wide variety of pollutants discharged by the OCPS industry, OCPS plants use a broad range of in-plant controls, process modifications and end-of-pipe treatment techniques. Most plants have implemented programs that combine elements of both in-plant control and end-of-pipe wastewater treatment. The configuration of controls and technologies differs from plant to plant, corresponding to the differing mixes of products manufactured by different facilities. In general, direct dischargers treat their wastes more extensively than indirect dischargers.

The predominant end-of-pipe control technology for direct dischargers in the OCPS industry is biological treatment. The chief forms of biological treatment are activatd sludge and aerated lagoons. Other systems, such as extended aeration and trickling filters, are also used, but less extensively. All of these systems reduce BOD and TSS loadings and, in many instances, incidentally remove toxic and nonconventional pollutants. Biological systems biodegrade some of the organic pollutants, remove bio-refractory organics and metals by sorption into the sludge, and strip some volatile organic compounds into the air.

Other end-of-pipe treatment technologies used in the OCPS industry include neutralization, equalization, polishing ponds, filtration and carbon adsorption. While most direct dischargers use these physical/chemical technologies in conjunction with end-of-pipe biological treatment, at least 39 direct dischargers use only physical/chemical treatment.

In-plant control measures employed at OCPS plants include water reduction and reuse techniques, chemical substitution and process changes. Techniques to reduce water use include the elimination of water use where practicable, and the reuse and recycling of certain streams, such as reactor and floor washwater, surface runoff, scrubber effluent and vacuum seal discharges. Chemical substitution is utilized to replace process chemicals possessing highly toxic or refractory properties by others that are less toxic or more amenable to treatment. Process changes include various measures that reduce water use, waste discharges, and/or waste loadings while improving process efficiency. Replacement of barometric condensers with surface condensers, replacement of steam jet ejectors with vacuum pumps, recovery of product or by-product by steam stripping, distillation, solvent extraction or recycle, oil-water separation and carbon adsorption, and the addition of spill control systems are examples of process changes that have been successfully employed in the OCPS industry to reduce pollutant loadings while improving process efficiencies.

Another type of control widely used in the OCPS industry is physical/chemical in-plant control. This treatment technology is generally used selectively on certain process wastewaters to recover products or process solvents, to reduce loadings that may impair the operation of the biological system or to remove certain pollutants that are not removed sufficiently by the biological system. In-plant technologies widely used in the OCPS industry include sedimentation/clarification, coagulation, flocculation, equalization, neutralization, oil/water separation, steam stripping, distillation and dissolved air flotation.

Many OCPS plants also use physical/chemical treatment after biological treatment. Such treatment is used in the majority of situations to reduce solids loadings that are discharged from biological treatment systems. The most common post-biological treatment systems are polishing ponds and multimedia filtration.

At approximately 5 percent of the direct discharging plants surveyed, no treatment is provided. At another 20 percent, only physical/chemical treatment is provided. The remaining 75 percent utilize biological treatment. Approximately 36 percent of biologically treated effluents are further treated by polishing ponds, filtration or other forms of physical/chemical control.

At approximately 52 percent of the indirect discharging plants surveyed, no treatment is provided. At another 39 percent, some physical/chemical treatment is provided. Nine percent have biological treatment.

CONCLUSIONS

BPT

Biological teatment has been identified as the best practicable control technology currently available for each of the four proposed subcategories. In general, the long-term median BPT final effluent BOD_5 and TSS concentrations were calculated for each subcategory by using the performance of plants which attain 95% BOD_5 reduction or a final effluent BOD_5 concentration less than or equal to 50 mg/l.

Maximum 30-day and daily maximum effluent limitations were determined by multiplying long-term median effluent limitations by appropriate variability factors which were calculated through statistical analysis of long-term BOD_5 and TSS daily data. This statistical analysis is described in detail in Section VII.

Proposed BPT limitations are presented in Table 2-1.

BCT

The 1977 amendments added Section 301(b)(2)(E) to the Act, establishing "best conventional pollutant control technology" (BCT) for discharges of conventional pollutants from existing industrial point sources. Section 304 (a)(4) designated the following as conventional pollutants: BOD, TSS, fecal coliform and pH. The Administrator designated oil and grease as "conventional" on July 30, 1979, 44 FR 44501.

EPA has proposed a BCT cost-reasonableness test which provides that BCT is cost-reasonable if: (1) the incremental cost per pound of conventional pollutant removed in going from BPT to BCT is less than $.27 per pound in 1976 dollars, and (2) this same incremental cost per pound is less than 143% of the incremental cost per pound associated with achieving BPT.

All the incremental costs per pound ratios were found to fail this first part of the BCT "cost-reasonableness" test ($0.33 per pound in 1979 dollars). Therefore, EPA did not perform the second part of the BCT "cost-reasonableness" test, and is proposing BCT effluent limitations which are equal to the BPT effluent limitations for each of the proposed BPT subcategories.

TABLE 2-1

BPT EFFLUENT LIMITATIONS
(mg/l or ppm)

	LONG TERM MEDIAN		MAXIMUM 30-DAY		MAXIMUM DAILY	
SUBCATEGORY	BOD_5	TSS	BOD5	TSS	BOD_5	TSS
Plastics Only	14.5	24	22	36	49	117
Oxidation						
o High Water Use	26	62	42	84	106	246
o Low Water Use	36	89	58	120	146	353
Type I	24.5	34.5	40	47	100	137
Other Discharges	17	29	28	39	69	115

NSPS

The basis for new source performance standards (NSPS) under Section 306 of the Act is the best available demonstrated technology. At new plants, the opportunity exists to design the best and most efficient production processes and wastewater treatment facilities. Therefore, Congress directed EPA to consider the best demonstrated process change, in-plant controls and end-of-pipe treatment technologies that reduce pollution to the maximum extent feasible. It is encouraged that at new sources reductions in the use of and/or discharge of wastewater be attained by application of in-plant control measures.

The technologies employed to control conventional pollutants at existing plants are fully applicable to new plants. In addition, no other technologies could be identified for new sources which were different from those used to establish BPT effluent limitations. Thus, the technology basis for NSPS is the same as that for BPT effluent limitations. For detailed information on the technology basis for BPT effluent limitations, refer to Section IX of this document.

Since the Agency could identify no additional generally applicable technology for NSPS, and since the technology basis for NSPS is the same as that identified for BPT effluent limitations, EPA has established NSPS effluent limitations equal to the proposed BPT and BCT effluent limitations.

SECTION III.

DESCRIPTION OF INDUSTRY

INTRODUCTION

The organic chemicals industry had very modest beginnings in the middle of the 19th century. The production of coke, used both as fuel and a reductant in blast furnaces for steel production, generated coal tar as a by-product. Although these tars were initially regarded as wastes, with the synthesis of the first coal tar dye (mauve) by Perkin in 1856, chemists and engineers began to look for ways to recover and use all industrial by-products.

With increasing numbers of chemical compounds possessing valuable properties being identified, commercial routes to these compounds became necessary. Not surprisingly, the early products of the chemical industry were those most desired by society: dyestuffs, explosives, and pharmaceuticals. The economic incentive to find markets for industrial wastes and by-products continued to be a driving force behind these industries. The chlorinated aromatic chemicals industry, for example, developed mainly out of: (1) the need to use the large quantities of chlorine formed as a by-product from caustic soda production, (2) the availability of benzene derived from coal tar, and (3) the discovery that such compounds could serve as useful intermediates for production of other, more valuable materials, e.g., phenol and picric acid. In time, specialty products such as surfactants, pesticides, and aerosol propellants were also developed.

The plastics and synthetic fibers industry began only somewhat later. The first commercial polymers, rayon and bakelite, were produced in the early 1900s from feedstocks manufactured by the organic chemicals industry. While the organic chemicals and plastics and synthetic fibers industries are regarded as separate, the latter is clearly an outgrowth of the organic chemicals industry. The variety of plastic and synthetic fiber products developed in the last decades and the diversity of markets and applications of these products have made the plastics and synthetic fibers industry the largest consumer of organic chemicals on a volume basis.

Coal derived chemicals were the principal feedstocks of the early industry (though ethanol, derived from fermentation, served as a source of some aliphatic compounds). The growth in the markets for organic chemicals and plastics and synthetic fibers led, in time, however to changes in the source of feedstocks for the industry. By World War II, the modern organic chemicals and plastics and synthetic materials industry based on petrochemicals was firmly established in the United States.

Today the industry is comprised of production facilities of two distinct types: those facilities whose primary function is chemical synthesis and plants that recover organic chemicals as a by-product from unrelated manufacturing operations such as steel production. The bulk of the industry is comprised of plants in the former category: plants that process chemical raw materials into a wide variety of products that permeate virtually every industrial and consumer market. Approximately 90% of the precursors, which are the primary feedstocks for all of the industry's thousands of products, are derived from petroleum and natural gas. The remaining 10% is supplied by plants that recover organic chemicals from coal tar condensates generated by coke production.

The apparent complexity and diversity of the organic chemical manufacturing industry can be simplified by recognizing that approximately 2,500 distinct chemical products are synthesized from only seven parent compounds--methane, ethylene, propylene, butane/butenes, benzene, toluene, and o,p-xylenes. These seven compounds are processed into derivatives which in turn are marketed or used as feedstocks for the synthesis of other derivatives. However, the product line of the industry is very complex with approximately 1,200 products that are produced in excess of one thousand pounds per year, and probably several thousand more that are produced in lesser quantities. Because these products are produced by one or more manufacturers using different synthetic routes, few plants are exactly alike in terms of either product or processes.

The early chemical industry used an assortment of general purpose equipment and operated very labor intensive batch processes that required relatively little capital investment. As the demand grew, around the time of World War II, the chemical production shifted to large scale continuous processing units because of technological improvement and also because of the economies of scale associated with large production facilities. This changed the industry to a high-capital-intensive, low-labor basis.

Although there is still a large number of small organics producers utilizing batch processes, these producers are usually dedicated to the manufacture of fairly small volumes of high-priced specialty products which may contribute substantially to the total value of organic chemical production, but is only a small portion of chemical production volume.

Since organic chemicals are produced both by large manufacturing complexes made up of continuous major processing units and by smaller batch process plants producing many different products, there is a wide variability of products and process units from one complex to another with treatment facilities typically servicing the complex rather than the individual process units. Among the hundreds of products made by the industry, there are derivative and coproduct relationships that result in groups of products commonly being made together.

DEFINITION OF THE INDUSTRY

It is difficult to profile the organic chemicals and plastics and synthetic fibers industries due to their complexity and diversity. However, traditional profiles can provide useful descriptions of the chemical industry. The following profile factors are discussed briefly in the ensuing subsections:

Standard Industrial Classification System (SIC)
Production and Sales
Geographic Location
Size of Plant
Age of Plant

Standard Industrial Classification System

One industrial profile commonly employed for collection of economic data for manufacturing industries is the Standard Industrial Classification (SIC) System. The organic chemicals and plastics and synthetic materials industrial categories are nominally described under SIC 2865 and 2869 for organic chemicals, and SIC 2821, 2823, and 2824 for plastics and synthetic materials. SIC codes as established by the U. S. Department of Commerce are "classifications of establishments by type of activity in which they are engaged." Each plant is "assigned an industry code on the basis of its primary activity which is determined by its principal product or group of products." However, as a practical matter, many plants can also have secondary, tertiary, or subsequent order SIC codes assigned to classify those activities in which they engage beyond their primary activities. Thus the inclusion of establishments with one of these SIC codes as primary, secondary, or subsequent classification would provide an all inclusive listing of establishments producing organic chemicals including such operations as steel mills, which are not intended to be controlled under the organic chemical industry guidelines. This classification system is oriented towards the collection of economic data related to gross production, sales, number of employees and geographic location.

Production and Sales

Estimates of the production volume and sales for the OCPS industry were made using the 1981 U. S. Department of Commerce statistics and are shown in Table 3-1. These estimates of production and sales include secondary as well as primary production. Primary products are those materials that comprise the largest portion of a facility's total production. Secondary production involves those products manufactured in smaller volumes as co-products, by-products or as raw materials for primary products. Therefore, these estimates reflect some double counting since certain secondary products are derived from products also included in the total (e.g., ethylene dichloride is included as well as the ethylene from which it is produced). Furthermore, the ITC presents statistics on products or groups of products within a specific use category. These use categories can contain products from more than one SIC code. Where possible, adjustments were made to exclude products not applicable.

The production volumes of the 29 organic chemicals included in the Chemical and Engineering News' 1980 Top 50 List of Chemicals are listed in Table 3-2. The total volume of production for these 29 organic compounds was 78.75 million kkg (173.66 billion lbs) or 60 percent of all organic chemicals productions (as shown in Table 3-1). Table 3-3 gives the production volumes of the "top" products in the plastics and synthetic fibers categories.

TABLE 3-1

ANNUAL PRODUCTION AND SALES BY SIC CODE

	SIC CODE	Production (million kkg)	Sales (billion dollars)
Organic Chemicals	2865	132	11.0
	2869		43.2
Plastics and Synthetic Materials	2821	27	16.1
	2823		1.2
	2824		8.7
TOTAL		159	80.2

SOURCE: U. S. Department of Commerce, 1981.

TABLE 3-2

ANNUAL PRODUCTION VOLUME OF ORGANIC CHEMICALS IN "TOP 50" LIST 1980

Rank	Chemical	Production (million kkg)
6	Ethylene	12.50
13	Urea	6.51
14	Propylene	6.22
15	Toluene	5.12
16	Benzene	4.98
17	Ethylene dichloride	4.53
18	Ethylbenzene	3.45
20	Methanol	3.18
21	Styrene	3.13
22	Vinyl chloride	2.93
23	Xylene	2.91
24	Terephthalic acid	2.69
25	Formaldehyde	2.62
27	Ethylene oxide	2.25
28	Ethylene glycol	1.92
30	p-Xylene	1.74
31	Cumene	1.43
32	Butadiene (1,3-)	1.31
33	Acetic acid	1.28
36	Phenol	1.12
38	Acetone	0.96
39	Cyclohexane	0.89
41	Vinyl acetate	0.87
42	Acrylonitrile	0.83
43	Isopropyl alcohol	0.81
44	Propylene oxide	0.80
46	Acetic anhydride	0.67
49	Ethanol	0.55
50	Adipic acid	0.55
TOTAL		78.75

SOURCE: Chemical and Engineering News 1981

TABLE 3-3

ANNUAL PRODUCTION VOLUME OF PLASTICS AND SYNTHETIC FIBERS
1980

Resin/Fiber	Production (million kkg)
Thermosetting resins	
Phenolic and other tar acid resins	0.68
Polyesters (unsaturated)	0.41
Urea resins	0.53
Expoxies (unmodified)	0.15
Melamine resins	0.08
Thermoplastic resins	
Low-density polyethylene	3.31
Polyvinyl chloride and copolymers	2.48
Polystyrene and copolymers	2.06
High-density polyethylene	2.00
Polypropylene and copolymers	1.66
Cellulosics	
Rayon	0.22
Acetate	0.15
Noncellulosics	
Polyester	1.81
Nylon	1.07
Glass fiber	0.39
Acrylic	0.35
Olefin	0.34
TOTAL	17.69

SOURCE: Chemical and Engineering News 1981

Manufacturing Sites and Geographic Distribution of Industry

The number of plants operating under each of the five primary SIC codes and classifications and the total number of organics and plastics and synthetic materials plants are shown in Table 3-4. Table 3-5 presents the distribution of these plants by state. It is not surprising that most organic chemical plants are located in the coastal regions near sources of raw materials. The plastics and synthetic materials industries generally follow this trend to minimize transportation costs of monomer feedstock. However, a significant number of plastic plants are situated near end product markets (i.e., large population centers) for the same reason.

The first column in Table 3-4 utilizes Economic Information System data which are based mainly on U. S. Department of Commerce statistics from the Bureau of Census on Manufacturers. These statistics concentrate on primary production facilities and estimates are used to predict the number of smaller facilities below certain employee levels. The second column represents an estimate of all OCPS facilities which attempt to take into account secondary production facilities. In estimating these plant counts, a number of information sources were used, including:

1. Permit listings supplied by NEIC-Denver and EPA's Office of Water Enforcement
2. 308 Questionnaire plant listings
3. EGD Telephone Survey of Plastics and Synthetic Materials facilities
4. Plant listings from the economic contractor
5. Economic Information Service (EIS) plant listings
6. Plant listings from EPA's Permit Compliance System (PCS)
7. Dunn & Bradstreet
8. TSCA inventories

In compiling plants from the above listings, the number of direct discharge plants was first obtained by cross-checking each of the available data sources. Non-direct discharge plants were projected utilizing ratios of non-direct to direct discharge plants from the 308 Questionnaire plant listings and the direct discharge plants as determined above. SIC code information as well as 308 Questionnaire and Telephone Survey data were used to group all plants into three broad industry segments: (1) plants manufacturing only organic chemicals, (2) plants manufacturing only plastics and synthetic materials, and (3) plants manufacturing both organic chemicals and plastics and synthetic materials in the same facility.

Except for EIS (which utilizes Census of Manufacturers statistics), each of these information sources is independent of the others and provides a

TABLE 3-4

OCPS PLANT DISTRIBUTION BY SIC CODE

Industry	SIC Code	Number of Plants*	Projected Estimate of Number of Plants
Organic Chemicals	2865	195	1045
Only	2869	457	
Plastics and	2821	484	879
Synthetic Materials	2823	19	
Only	2824	62	
Organic Chemicals & Plastics and Synthetic Materials (Combined)			176
TOTAL		1217	2100

* SOURCE: Economic Information Service (1981)

TABLE 3-5

PLANT DISTRIBUTION BY STATE

	Organics Chemicals Industry			Plastics and Synthetic Fibers Industry			
	SIC CODE			SIC CODE			
	2865	2969	Total	2821	2323	2324	Total
STATE							
Alabama	4	5	9	7	1	2	10
Alaska	0	1	1	0	0	0	0
Arizona	0	1	1	1	0	0	1
Arkansas	1	3	4	5	0	1	6
California	6	30	36	45	0	1	46
Colorado	1	4	5	3	0	0	3
Connecticut	0	8	8	11	0	3	14
Delaware	1	5	6	12	0	1	13
Florida	3	6	9	7	0	2	9
Georgia	1	6	7	7	1	5	13
Hawaii	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0
Illinois	12	32	44	28	1	1	30
Indiana	4	4	8	7	1	1	9
Iowa	0	2	2	4	0	0	4
Kansas	2	3	5	1	0	0	1
Kentucky	2	8	10	5	0	0	5
Louisiana	3	33	36	10	0	0	10
Maine	0	0	0	1	0	0	1
Maryland	0	4	4	3	1	1	5
Massachusetts	7	14	21	32	0	2	34
Michign	3	16	19	16	1	0	17
Minnesota	1	3	4	3	0	0	3
Missouri	1	7	8	8	0	0	8
Mississippi	3	1	4	6	0	1	7
Montana	0	1	1	1	0	0	1
North Carolina	12	11	23	12	0	11	23
North Dakota	0	0	0	0	1	0	1
Nebraska	0	2	2	0	0	0	0
New Hampshire	1	2	3	4	0	0	4
New Jersey	48	67	115	60	1	1	62
New Mexico	0	1	1	0	0	0	0
Nevada	0	2	2	1	0	0	1
New York	10	27	37	24	1	1	26

TABLE 3-5 (Continued)

PLANT DISTRIBUTION BY STATE

	Organic Chemicals Industry			Plastics and Synthetic Fibers Industry			
	SIC CODE			SIC CODE			
	2865	2869	Total	2821	2323	2324	Total
STATE							
Ohio	18	19	37	43	2	1	46
Oklahoma	0	2	2	5	0	0	5
Oregon	0	4	4	4	0	0	4
Pennsylvania	12	21	33	31	2	0	33
Puerto Rico	3	9	12	4	0	3	7
Rhode Island	5	6	11	1	0	0	1
South Carolina	10	9	19	5	1	15	21
South Dakota	0	0	0	0	0	0	0
Tennessee	1	5	6	7	2	4	13
Texas	17	57	74	35	0	0	35
Utah	1	0	1	2	0	0	2
Virginia	1	4	5	5	2	7	14
Vermont	0	0	0	1	0	0	1
Washington	2	4	6	5	1	0	6
Wisconsin	0	6	6	9	0	0	9
West Virginia	1	11	12	7	0	1	8
Wyoming	1	0	1	0	0	0	0
TOTAL	198	466	664	488	19	65	572

SOURCE: Continental United States (EIS 1981); Puerto Rico (Bureau of the Census 1977) fairly accurate estimate of both primary and secondary production facilities.

Plant Size

Sales volume, number of employees, area of plant site, plant capacity (design or "nameplate" capacity) and production rate are factors that logically would be considered to define plant size. However, none of these completely describes plant size in a manner satisfactory for all purposes. Each of these definitions are discussed below.

Often, number of workers employed will be used as an indication of the relative size of a facililty. However, continuous plants producing commodity (i.e., high volume) chemicals typically employ fewer workers per unit of production than do plants producing specialty (i.e., relatively low volume) chemicals. Also, the area of a plant site can be very misleading when considering it for determining plant size. Some plants are built on enormous lots of land but only take up a small portion of that land, while other plants may utilize the entire lot. Sales volume does not accurately define plant size since it is totally dependent on the demand for certain products or the demand for goods produced from those chemical products. Demand may then be dependent on prices and the economy, with sales volume fluctuating becasue of outside variables, and therefore not relating to a plant or its size.

Table 3-6 and Figure 3-1 present the plant distribution of the organic chemicals and plastics and synthetic materials industries based upon number of employees. Table 3-7 and Figure 3-2 present plant distribution based on sales volume.

For the purposes of this report, plant size cannot be sufficiently defined based on plant or design capacity due to the often broad differences between a plant's design capacity or rate and its average production rate per year. Therefore, plant size for this evaluation is best described by the average production (lbs/day) while operating, as reported in the 308 Questionnaire. Production data on an industry-wide basis is not available. However, a summary and analysis of the 308 production data is presented in Section IV.

Plant Age

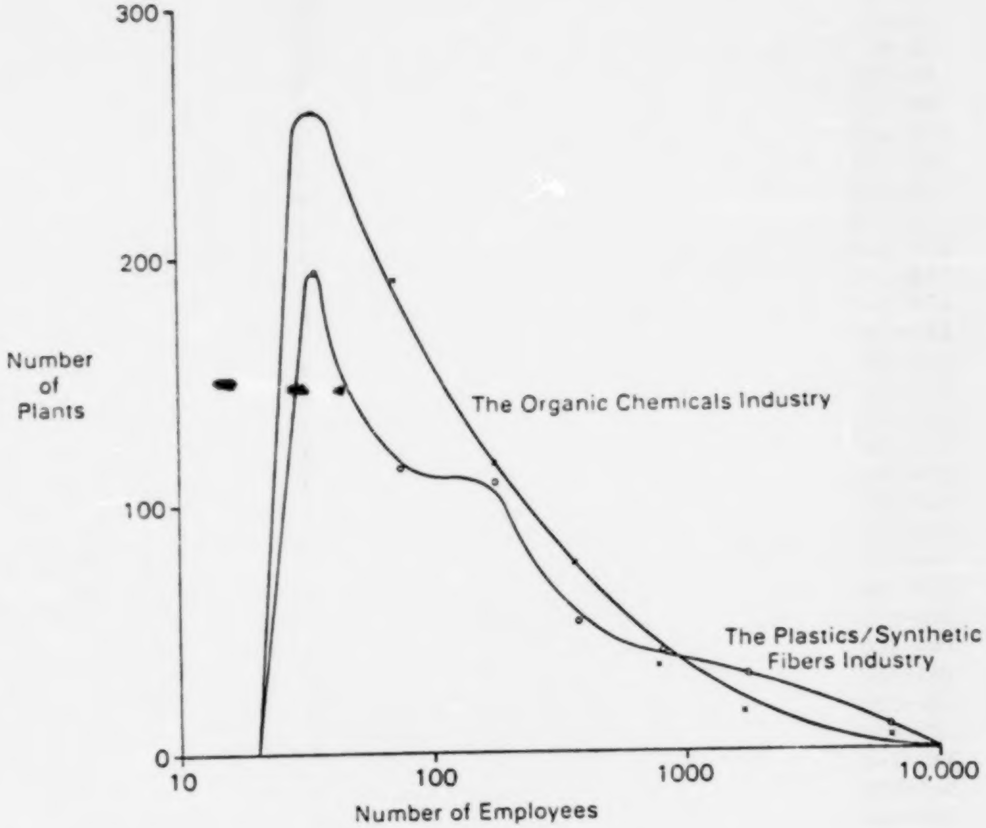
Plant age within the organic chemicals and plastics and synthetic materials industries is difficult to define since such plants evolve over extended periods of time by additions of product/processes, increases in production rates or changes in technology for the existing product lines. Because new products are continually being introduced by the industry, process units are added to satisfy a growing product demand. Plant age is problematic at such plants, i.e., which process should be chosen to define plant age? Typically, the oldest process in current operation is used to define plant age. Information concerning plant age is not available in the literature and has been compiled from the 308 data base. Table 3-8 and Figure 3-3 illustrate the age (as defined above) of manufacturing facilities within these industries.

TABLE 3-6

PLANT DISTRIBUTION BY EMPLOYMENT SIZE

Number of Employees	Number of Organic Chemicals Plants		Number of Plastics and Synthetic Fibers Plants		
	SIC CODE		SIC CODE		
	2865	2869	2821	2323	2824
20-49	77	181	184	4	7
50-99	45	96	107	4	6
100-249	38	79	101	0	9
250-499	23	53	45	1	8
500-999	9	28	30	5	7
1000-2499	3	14	16	3	17
2500-9999	0	6	1	2	8

SOURCE: EIS 1981



PLANT DISTRIBUTION BY NUMBER OF EMPLOYEES

FIGURE 3-1

TABLE 3-7

PLANT DISTRIBUTION BY SALES VOLUME

Sales (million dollars)	Number of Plants Organic	 Plastics
1-10	217	287
10-20	137	86
20-30	76	53
30-40	42	29
40-50	28	14
50-60	17	13
60-70	20	8
70-80	19	5
80-90	11	6
90-100	9	6
100-110	7	5
110-120	8	4
120-130	5	4
130-140	9	4
140-150	2	3
150-160	2	2
160-170	4	3
170-180	4	2
180-190	3	1
190-200	2	3
200-210	-	1
210-220	1	-
220-230	2	-
230-240	1	1
240-250	2	4
250-260	-	1
260-270	3	1
270-280	-	2
280-290	-	2
290-300	1	2
300-310	-	-
310-320	2	2
320-330	2	-
330-340	1	-
340-350	1	-
350-360	1	1
360-370	-	2
370-380	-	-
380-390	1	-
390-400	-	-

TABLE 3-7 (Continued)

PLANT DISTRIBUTION BY SALES VOLUME

Sales (million dollars)	Number of Plants Organic	Plastics
400-410	1	1
410-420	1	3
450-460	1	-
470-480	1	-
480-490	1	-
580-590	1	-
640-650	-	1
670-680	1	-
690-700	1	-
730-740	-	1
780-790	1	-
920-930	1	-
1240-1250	1	-
1850-1860	1	-

PLANT DISTRIBUTION BY SALES VOLUME

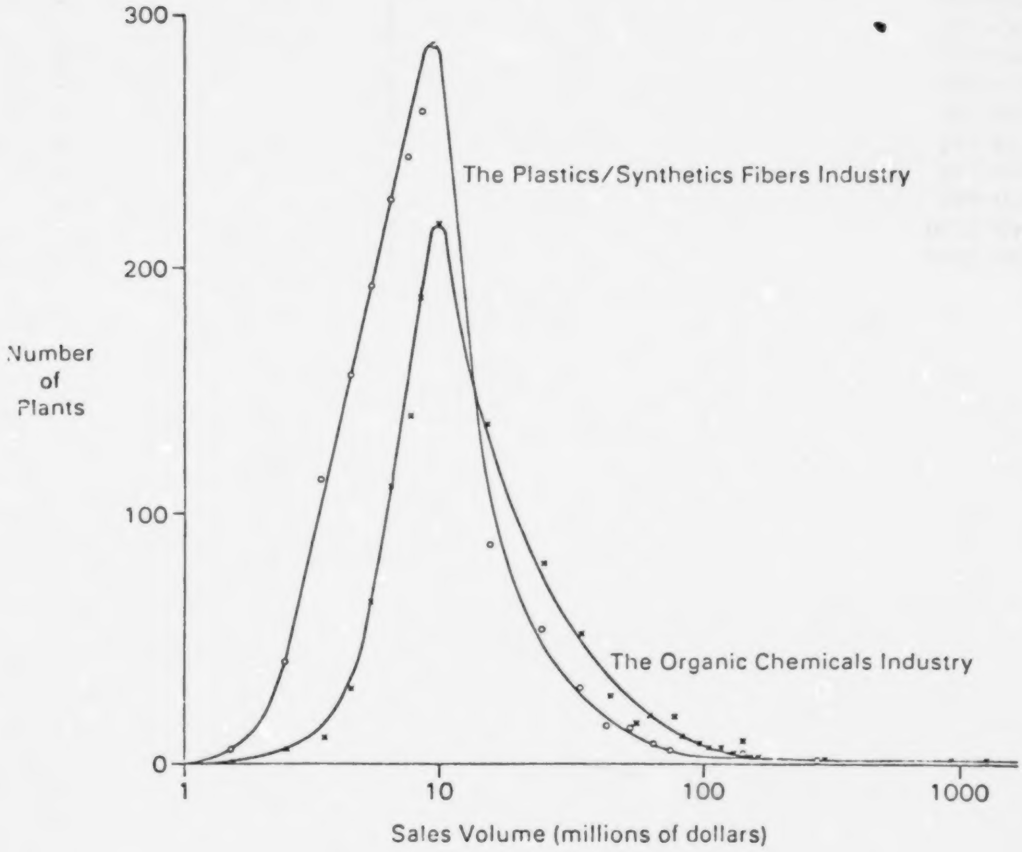


FIGURE 3-2

TABLE 3-8

DISTRIBUTION BY AGE OF ORGANIC CHEMICALS AND PLASTICS AND SYNTHETIC MATERIALS PLANTS

Age in Years	Number of Plants
0-5	18
6-10	44
11-15	61
16-20	53
21-25	44
26-30	22
31-35	17
36-40	11
41-45	5
46-50	2
51-55	3
56-60	1
61-65	1
TOTAL	282

DISTRIBUTION BY AGE OF ORGANIC CHEMICALS AND PLASTICS/SYNTHETIC FIBERS PLANTS

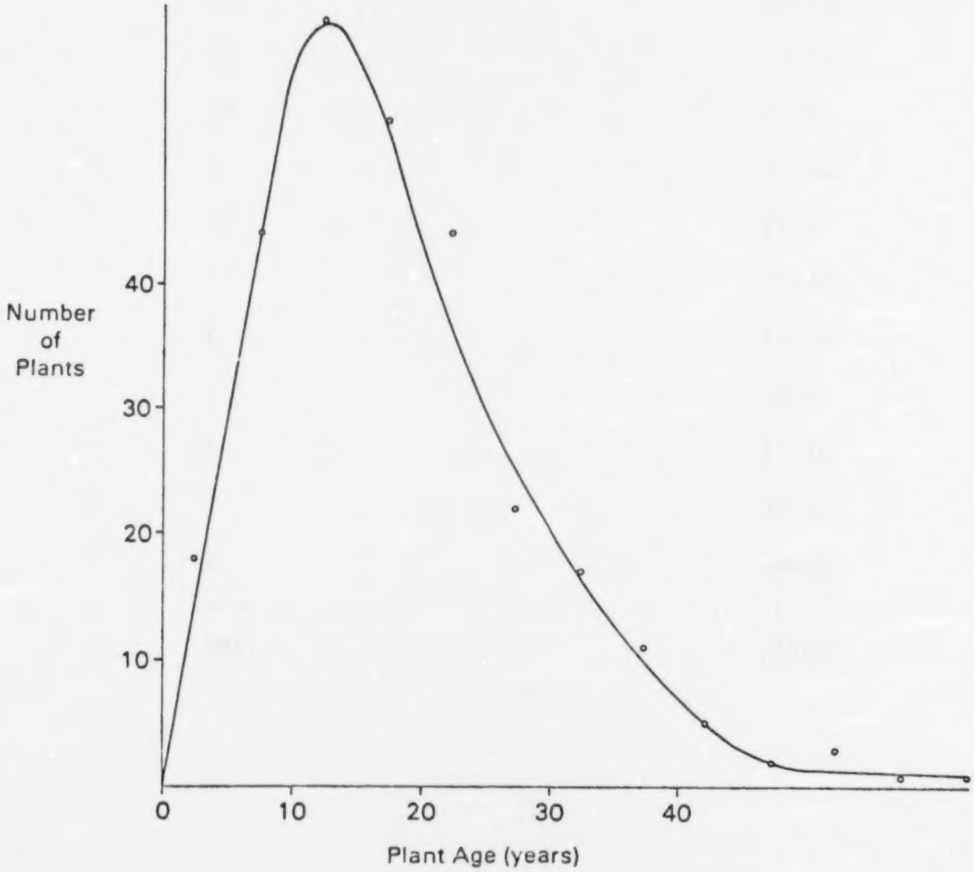


FIGURE 3-3

PRODUCT/PROCESS DESCRIPTION

Synthetic organic chemicals are derived from petroleum, natural gas, and coal by some type of chemical reaction (e.g., oxidation, hydrogenation, halogenation, alkylation). The chemical process and its variations can produce an enormous number of potential organic products from a simple list of starting materials.

Petrochemicals are the major raw materials used to produce many organic products. Five major sources (methane, ethylene, propylene, and higher aliphatics and aromatics) are utilized in organic chemical production.[3-1] This list is extended when such aromatics as benzene, toluene, and xylenes used for manufacture are included. A small number of these aromatics are derived from coal, but most raw materials evolve from petroleum and natural gas. In fact, 90 percent (by weight) of all organics are derived from these latter two sources.[3-2] Other raw materials are derived from coal and some naturally occurring renewable sources, notably fats, oils, and carbohydrates. Obscure natural products used as raw materials contribute to specialty chemical production within the organics industry.

Methane, one of the seven basic raw materials, is one of the least complex of the organic chemicals. Even using this simple compound, however, a series of increasingly complex chemicals can be made (see Figure 3-4).

As the chemical complexity of a raw material increases, the variety and number of potential products and chemical intermediates tend to increase also (see Figures 3-5 through 3-8 for the products and intermediates from the raw materials ethylene, propylene, C_4 hydrocarbons and higher aliphatics, and the aromatics). Most of the organic chemicals and plastics and synthetics produced in the U. S. are derived from relatively few basic raw materials, which come almost entirely from petroleum and natural gas.

Even though a portion of the raw materials is derived from other sources (such as coal), these materials are subjected to similar chemical manipulations and appear in the same series of intermediates and products.

Delineation between raw materials and products is difficult to determine at best, since the product from one manufacturer can be the raw material for another manufacturer. This lack of distinction is more pronounced as the process series approaches the ultimate end product, which is normally the fabrication or consumer stage. Also, many products/intermediates can be made from more than one raw material (a specific example of this is acetone which is produced from such raw materials as propylene, C_4 hydrocarbons, and aromatics). Frequently, there are alternate processes by which a product can be made from the same basic raw material.

Another characteristic which makes profiling the OCPS industry by raw material, process, or product difficult is the high degree of integration in the manufacturing units. Since the bulk of the basic raw materials are derived from petroleum or natural gas, many of the organic chemical manufacturing plants are incorporated into petroleum refiner-

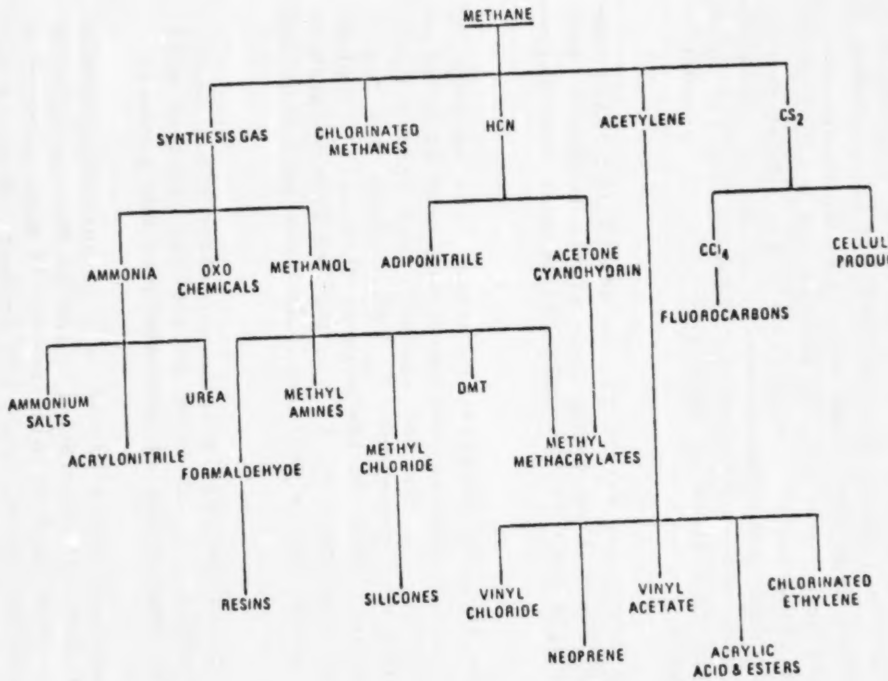

METHANE
SYNTHESIS GAS
CHLORINATED METHANES
HCN
ACETYLENE
CS_2
AMMONIA
OXO CHEMICALS
METHANOL
ADIPONITRILE
ACETONE CYANOHYDRIN
CCl_4
CELLULOSE PRODUCTS
FLUOROCARBONS
AMMONIUM SALTS
UREA
METHYL AMINES
DMT
ACRYLONITRILE
FORMALDEHYDE
METHYL CHLORIDE
METHYL METHACRYLATES
RESINS
SILICONES
VINYL CHLORIDE
VINYL ACETATE
CHLORINATED ETHYLENE
NEOPRENE
ACRYLIC ACID & ESTERS

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FIGURE 3-4 - SOME PRODUCTS DERIVED FROM METHANE

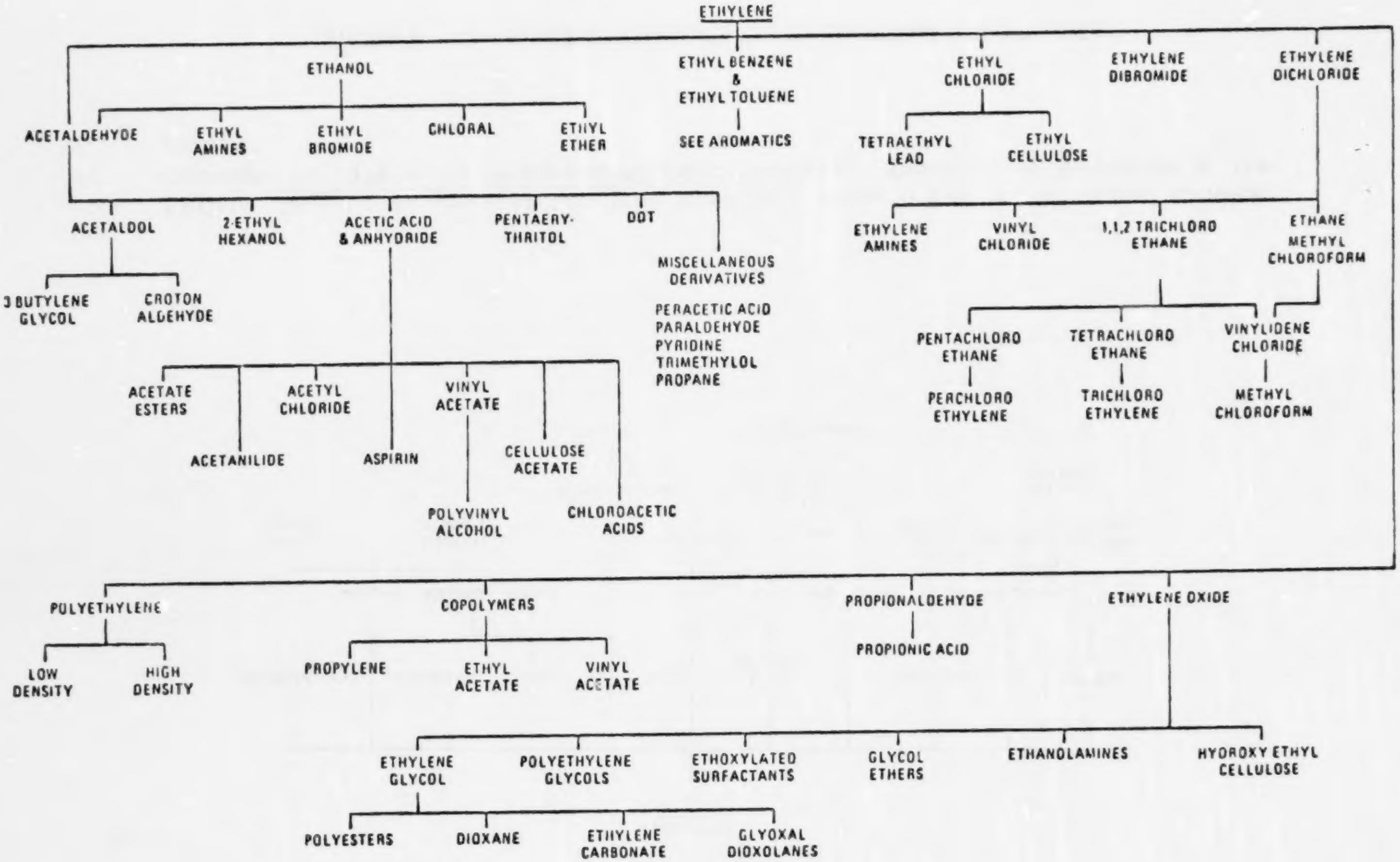
ETHYLENE
ACETALDEHYDE
ETHANOL
ETHYL AMINES
ETHYL BROMIDE
CHLORAL
ETHYL ETHER
ETHYL BENZENE & ETHYL TOLUENE
SEE AROMATICS
ETHYL CHLORIDE
TETRAETHYL LEAD
ETHYL CELLULOSE
ETHYLENE DIBROMIDE
ETHYLENE DICHLORIDE
ACETALDOL
3 BUTYLENE GLYCOL
CROTON ALDEHYDE
2-ETHYL HEXANOL
ACETIC ACID & ANHYDRIDE
PENTAERYTHRITOL
DDT
MISCELLANEOUS DERIVATIVES
PERACETIC ACID
PARALDEHYDE
PYRIDINE
TRIMETHYLOL PROPANE
ACETATE ESTERS
ACETANILIDE
ACETYL CHLORIDE
ASPIRIN
VINYL ACETATE
POLYVINYL ALCOHOL
CELLULOSE ACETATE
CHLOROACETIC ACIDS
ETHYLENE AMINES
VINYL CHLORIDE
1,1,2 TRICHLORO ETHANE
ETHANE METHYL CHLOROFORM
PENTACHLORO ETHANE
PERCHLORO ETHYLENE
TETRACHLORO ETHANE
TRICHLORO ETHYLENE
VINYLIDENE CHLORIDE
METHYL CHLOROFORM
POLYETHYLENE
LOW DENSITY
HIGH DENSITY
COPOLYMERS
PROPYLENE
ETHYL ACETATE
VINYL ACETATE
PROPIONALDEHYDE
PROPIONIC ACID
ETHYLENE OXIDE
ETHYLENE GLYCOL
POLYESTERS
DIOXANE
ETHYLENE CARBONATE
GLYOXAL DIOXOLANES
POLYETHYLENE GLYCOLS
ETHOXYLATED SURFACTANTS
GLYCOL ETHERS
ETHANOLAMINES
HYDROXY ETHYL CELLULOSE

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FIGURE 3-5 - SOME PRODUCTS DERIVED FROM ETHYLENE

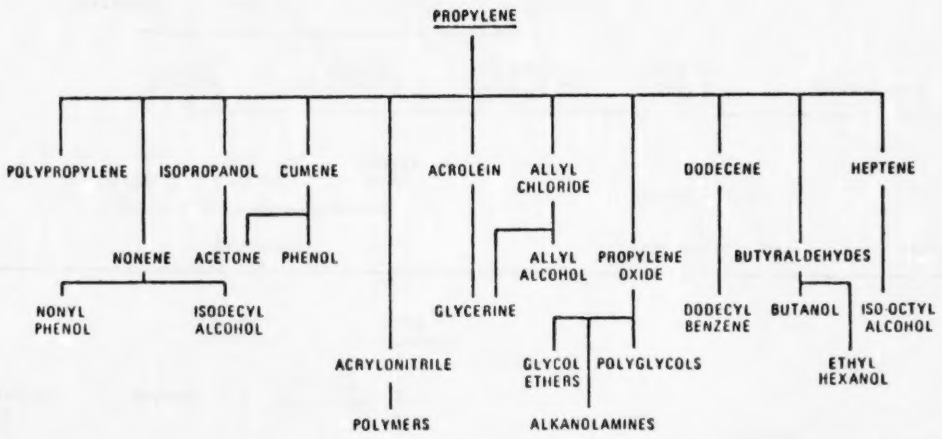
PROPYLENE
POLYPROPYLENE
ISOPROPANOL
CUMENE
ACROLEIN
ALLYL CHLORIDE
DODECENE
HEPTENE
NONENE
ACETONE
PHENOL
ALLYL ALCOHOL
PROPYLENE OXIDE
BUTYRALDEHYDES
NONYL PHENOL
ISODECYL ALCOHOL
GLYCERINE
DODECYL BENZENE
BUTANOL
ISO-OCTYL ALCOHOL
ACRYLONITRILE
GLYCOL ETHERS
POLYGLYCOLS
ETHYL HEXANOL
POLYMERS
ALKANOLAMINES

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FIGURE 3-6 - SOME PRODUCTS DERIVED FROM PROPYLENE

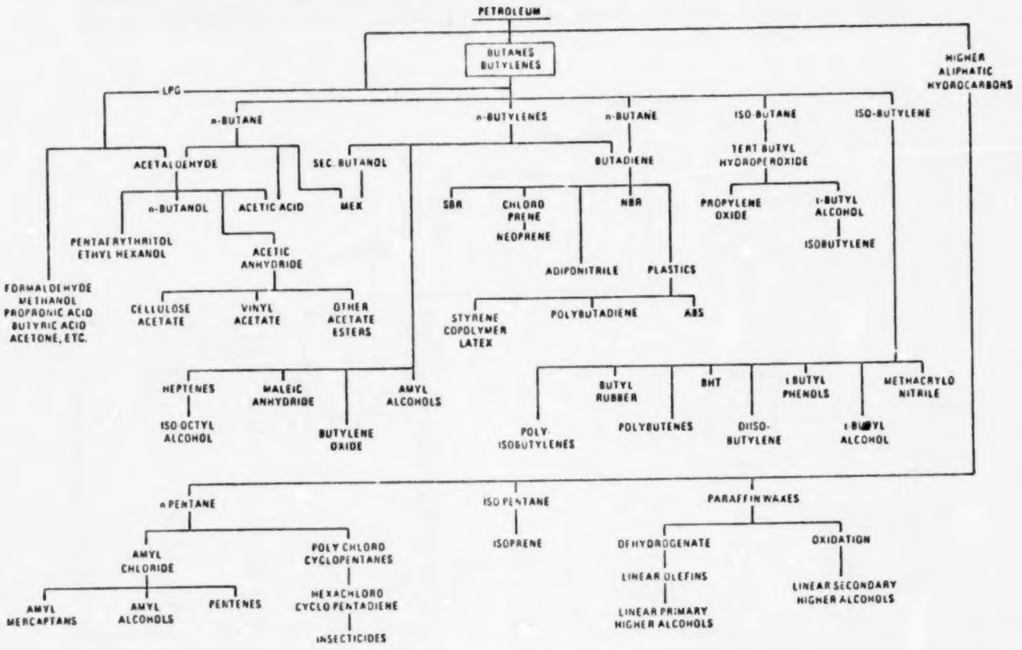
PETROLEUM
BUTANES BUTYLENES
HIGHER ALIPHATIC HYDROCARBONS
LPG
n-BUTANE
n-BUTYLENES
n-BUTANE
ISO-BUTANE
ISO-BUTYLENE
ACETALDEHYDE
SEC. BUTANOL
BUTADIENE
TERT BUTYL HYDROPEROXIDE
n-BUTANOL
ACETIC ACID
MEK
SBR
CHLORO PRENE
NEOPRENE
NBR
PROPYLENE OXIDE
t-BUTYL ALCOHOL
ISOBUTYLENE
PENTAERYTHRITOL ETHYL HEXANOL
ACETIC ANHYDRIDE
ADIPONITRILE
PLASTICS
FORMALDEHYDE METHANOL PROPRONIC ACID BUTYRIC ACID ACETONE, ETC.
CELLULOSE ACETATE
VINYL ACETATE
OTHER ACETATE ESTERS
STYRENE COPOLYMER LATEX
POLYBUTADIENE
ABS
HEPTENES
MALEIC ANHYDRIDE
AMYL ALCOHOLS
BUTYL RUBBER
BHT
t BUTYL PHENOLS
METHACRYLO NITRILE
ISO OCTYL ALCOHOL
BUTYLENE OXIDE
POLY-ISOBUTYLENES
POLYBUTENES
DIISO-BUTYLENE
t-BUTYL ALCOHOL
n PENTANE
ISO PENTANE
PARAFFIN WAXES
AMYL CHLORIDE
POLY CHLORO CYCLOPENTANES
ISOPRENE
DEHYDROGENATE
OXIDATION
HEXACHLORO CYCLO PENTADIENE
LINEAR OLEFINS
LINEAR SECONDARY HIGHER ALCOHOLS
AMYL MERCAPTANS
AMYL ALCOHOLS
PENTENES
INSECTICIDES
LINEAR PRIMARY HIGHER ALCOHOLS

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FIGURE 3-7 - SOME PRODUCTS DERIVED FROM C_4 AND HIGHER ALIPHATICS

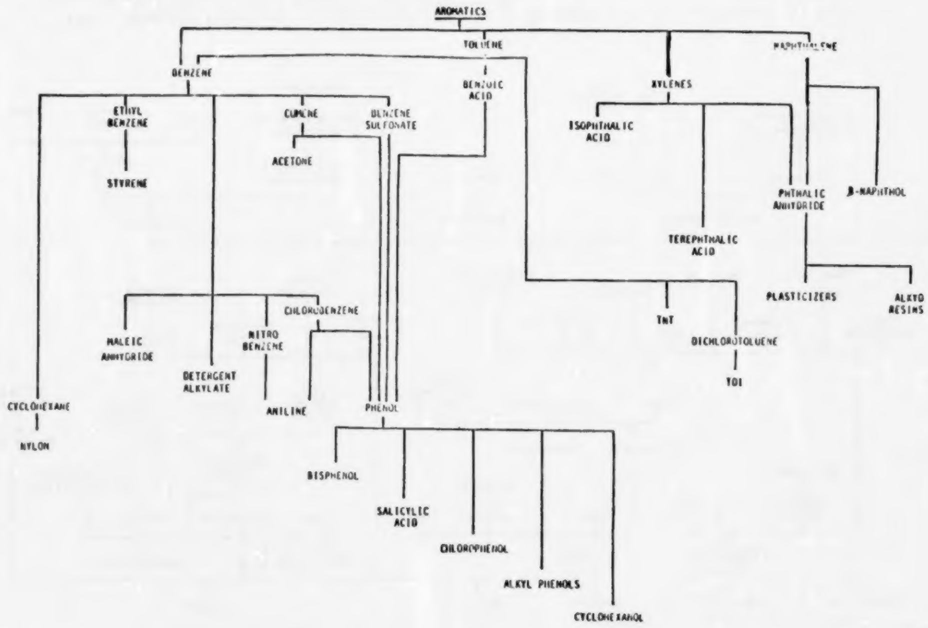
AROMATICS
BENZENE
TOLUENE
XYLENES
NAPHTHALENE
ETHYL BENZENE
STYRENE
CUMENE
ACETONE
BENZENE SULFONATE
BENZOIC ACID
ISOPHTHALIC ACID
TEREPHTHALIC ACID
PHTHALIC ANHYDRIDE
B-NAPHTHOL
PLASTICIZERS
ALKYD RESINS
TNT
DICHLOROTOLUENE
TDI
MALEIC ANHYDRIDE
DETERGENT ALKYLATE
NITRO BENZENE
CHLOROBENZENE
ANILINE
CYCLOHEXANE
NYLON
PHENOL
BISPHENOL
SALICYLIC ACID
CHLOROPHENOL
ALKYL PHENOLS
CYCLOHEXANOL

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FIGURE 3-8 - SOME PRODUCTS DERIVED FROM AROMATICS

ies, and may produce to almost any point in a process from any or all of the basic raw materials. Normally, relatively few organic chemicals manufacturing facilities are single product/process plants unless the final product is near the fabrication or consumer product stage.

This generalized configuration, of which the bulk of the organics industry is comprised, is commonly referred to as a petrochemical complex. Processing arrangements within petrochemical complexes can be quite similar on a worldwide basis since a variety of raw materials, intermediates or finished products is relatively common in the larger scale manufacturing facilities. Furthermore, several processing units are characteristically integrated in such a fashion that the relative amounts of products can be varied as desired over wide ranges.

The capacity of individual plants can change over time. Plants are often modified to produce other products, increase capacity, or produce the same product by a different synthesis route. Some plants or companies exhibit a pronounced degree of vertical integration, while other plants or companies may only produce a limited number of products from one basic chemical raw material. Plant capacities are highly variable even among those plants that use the same unit process to produce the same product.

Wastewater Generation

Chemical and plastics manufacturing plants share an important characteristic: chemical processes never convert 100 percent of the feed stocks to the desired products, since the chemical reactions/processes never proceed to total completion. Moreover, because there are generally a variety of reaction pathways available to reactants, undesirable by-products are often generated. This produces a mixture of unreacted raw materials, products and by-products that must be separated and recovered by operations that generate residues with little or no commercial value. These losses appear in process wastewater, in air emissions, or directly as chemical wastes. The specific chemicals that appear as losses are determined by the feedstock and the process chemistry imposed upon it. The different combinations of products and production processes distinguish the wastewater characteristics of one plant from that of another.

Plastic Plants vs. Non-Plastic Plants

In contrast to organic chemicals, plastics and synthetic fibers are polymeric products. Their manufacture directly utilizes only a small subset of either the chemicals manufactured or processes used within the Organic Chemical Industry. Such products are manufactured by polymerization processes in which organic chemicals (monomers) react to form macromolecules or polymers, composed of thousands of monomer units. Reaction conditions are designed to drive the polymerization as far to completion as practical and to recover unreacted monomer. Unless a solvent is used in the polymerization, by-products of polymeric product manufactures are usually restricted to the monomer(s) or to oligomers (a polymer consisting of only a few monomer units). Because the mild reaction conditions generate few by-products, there is economic incentive to recover the monomer(s) and oligomers for recycle. The principal yield loss is typically scrap polymer. Thus, smaller amounts of fewer organics chemical co-products (pollutants) are generated by the production of polymeric plastics and synthetic fibers, than are generated by the manufacture of the monomers and other organic chemicals. A logical first subcategorization step is to separate production of plastics from all other production processes. The subcategorization of the remaining organics and mixed plastics-organics processes is evaluated below.

Generic Processes and Product/Processes

Despite the differences between individual chemical production plants, all transform one chemical to another by chemical reactions and physical processes. Though each transformation represents at least one chemical reaction, production of virtually all the industry's products can be described by one or more of 41 generalized chemical reactions/processes shown in Table 3-9. Subjecting the basic feedstocks to sequences of these 41 generic processes produces all the commercial organic chemicals and plastics.

Each chemical product may be made by one or more combinations of raw feedstock and generic process sequences. Specification of the sequence of product synthesis by identification of the products and the generic process by which it is produced is called a "product/process." There are thousands of product/processes within these industries. Data gathered on the nature and quantity of pollutants associated with the manufacture of specific products within the Organic Chemicals and Plastics/Synthetic Fibers Industries have been indexed by product/process.

Thus, while the industry may be examined on the basis of a plant's capacity, age, size, location, or number of employees, it is the mixture of products and the processes by which they are made that distinguishes the wastewater characteristics of one plant from that of another. Product/processes are a fundamental descriptor by which data concerning the nature and quantity of pollutants associated with the manufacture of specific products have been gathered. There are, however, thousands of industrial product/process combinations which would have to be evaluated to define the pollutant discharge potential for the entire industry. Evaluation of each for overall wastewater yield losses, to say nothing of identifying the pollutant loadings in the plant effluent, is unnecessarily difficult and burdensome.

The premise of the generic approach is that a generic process once characterized in one or more plants for generation of process wastes (yield losses) can be extended to similar generic processes throughout the industry. Given that biological treatment is widely practiced by direct dischargers (and ultimately by indirect dischargers as well), there is a strong inference that pollutant loadings characteristic of generic processes have similar treatabilities. The bulk of chemical processes employed commercially, moreover, can be limited to a number of generic processes, and this procedure can serve as the basis for relatively simple characterization of the OCPS industry. The great advantage of a generic approach, as applied to effluent regulation within the organic chemicals and plastics and synthetic materials industries, is the struc

TABLE 3-9

GENERIC CHEMICAL PROCESSES AND CODES

1. Oxidation (C)
2. Peroxidation (8)
3. Acid Cleavage (9)
4. Condensation (A)
5. Isomerization (22)
6. Esterification (G)
7. Hydroacetylation (13)
8. Hydration (12)
9. Alkoxylation (5)
10. Hydrolysis (E)
11. Carbonylation (O)
12. Hydrogenation (F)
13. Neutralization (24)
14. Amination (6)
15. Ammonolysis (K)
16. Oximation (10)
17. Dehydration (Q)
18. Ammoxidation (N)
19. Electrohydrodimerization (19)
20. Cyanation/Hydrocyanation (7,18)
21. Epoxidation (21)
22. Etherification (14)
23. Polymerization (D)
24. Alkylation (I)
25. Dehydrogenation (J)
26. Sulfonation (M)
27. Nitration (L)
28. Hydrodealkylation (U)
29. Pyrolysis (H)
30. Cracking (T)
31. Distillation (2)
32. Extractive Distillation (15)
33. Extraction (16)
34. Crystallization/Distillation (17)
35. Fiber Production (23)
36. Halogenation (B)
37. Oxyhalogenation (S)
38. Hydrohalogenation (P)
39. Dehydrohalogenation (R)
40. Chlorohydrination (20)
41. Phosgenation (V)

OTHER CLASSIFICATIONS

Non OCPS Product/Processes (3)

Cannot Be Classified (2)

turing of existing data within a framework which allows extrapolation to processes not explicitly evaluated.

The extent to which process yield losses can be correlated with generic process types depends on the ability to evaluate the chemical reaction system. The evaluation must include a full consideration of the process chemistry with a wide range of feedstocks and reaction conditions. Some of the fundamental concepts of this procedure are presented in the following discussion.

Manufacture of a chemical product necessarily consists of three steps: (1) combination of reactants, under suitable conditions, to yield the desired product, (2) separation of the product from the reaction matrix (e.g., by-products, co-products, reaction solvent), and (3) final purification of the product. Among the basic concepts that can be employed to limit the scope of pollutants expected from a plant are: (1) conservation of mass, (2) principles of thermodynamics, and (3) kinetic or mechanistic analyses.

In general, chemical species do not react via a single reaction pathway. Depending on the nature of the reactive intermediate, there are a variety of pathways which lead to a series of reaction products. Often, and certainly the case for reactions of industrial significance, one pathway may be greatly favored over all others, but never to total exclusion. Thus, by appropriate process design and proper control of reaction conditions, product yield is maximized. There are two fundamental sources of pollutants within a process: pollutants formed as the result of alternate reaction pathways; and reaction, by either the main or alternate reaction pathways, of impurities present in feedstocks. With regard to the latter, it is important to realize that even though feedstock impurities may be inert under a given set of reaction conditions, the direct discharge of such impurities to the environment may still represent a significant pollution potential.

Potentially, an extremely wide variety of compounds could form within a given process. The formation of expected products from known reactants is controlled thermodynamically while the rate at which such transformations occur depends upon the existence of suitable reaction pathways. Detailed thermodynamic calculations are of limited value in predicting the entire spectrum of products produced in a process. Both the identity of true reacting species and the assumption of equilibrium between reacting species are often speculative. Also, kinetic data concerning minor side reactions are generally unavailable. Thus, neither thermodynamic nor kinetic analyses alone can be used for absolute prediction of pollutant formation. However, these analyses do provide a framework within which pollutant loadings may be considered and generalized.

The direction of reactions in a process sequence is controlled through careful adjustment and maintenance of conditions in the reaction vessel.

The physical condition of species present (liquid, solid, or gaseous phase), conditions of temperature and pressure, the presence of solvents and catalysts, and the configuration of process equipment dictate the kinetic pathway by which a particular reaction will proceed. From this knowledge it is possible to identify reactive intermediates and thus anticipate species (potential pollutants) formed.

To produce a complete and valid descriptor using the generic methodology, the initial feedstock and each generic process used to produce a final product must be specified. For commodity chemicals, generally it is sufficient to specify a feedstock and a single generic process. Nitration of benzene to produce nitrobenzene, for example, is sufficient description to predict composition of process wastewaters: nitrophenols will be the principal process wastewater constituents. Other compounds, however, may involve several chemical reactions and require a fuller description. For example, acetic acid and its anhydride can be produced by first manufacturing acetaldehyde by the hydration of acetelene, followed by the oxidation of acetaldehyde to acetic acid and acetic anhydride.

This example is relatively simple and manufacture of speciality chemicals is more complex. Thus, as individual chemicals become further removed from the basic feedstocks of the industry, fuller description is required for unique specification of process wastewaters. Limited plant data, however, were available by which to assign generic processes to a product, and in many cases the product was specified while the feedstock was not.

In such cases a generic process assignment was made on the basis of process chemistry and engineering, i.e., judgment was made as to the feedstock and chemistry employed at the plant. In no case, however, was more than one generic process assigned to a given product within a production line.

Appendix A presents the product/process frequency counts for the 308 Summary Data Base for direct dischargers, and zero dischargers and alternative disposal plants by each of the 41 generic product/processes.

DATA BASE PROFILE

Introduction

Despite the wide range of plant sizes, the diversity of plant specific product/processes, and the dynamic nature of technological innovations and market conditions, the OCPS industry is characterized using the latest available data from the industry and published sources.

Most of the data used for the engineering analysis in this report are extracted from the industry responses to the 1976 BPT questionnaire and the subsequent 1977 BAT questionnaire. The data from these questionnaires were transcribed on a plant-by-plant basis to a computer tape. The transcribed data for each plant were then computer printed and the individual data were submitted from December 1979 to January 1980 to the plants for review and comments. Also, long-term daily pollutant raw waste and final effluent data were collected and transcribed to the computer at this time.

Additionally, some qualitative information on the generation of wastewater and mode of discharge at 301 plastics manufacturing facilities was obtained by a supplemental telephone survey. It was also determined whether these plants produced resins and polymers which should be included in the data bases or whether the operations were limited to extrusion and/or fabrication of plastics.

The data sources included in this analysis are as follows:

1. The Telephone Survey data from the 301 plastic manufacturing plants, 251 of which were not covered in the 308 Data Base. This survey consistently determined the mode of discharge (direct, indirect, zero), location, and general product type. Thirty seven of the plants contacted were identifiable as extruding or otherwise fabricating plastics from purchased polymers. At the present time, the data from these 37 plants are included only in the mode of discharge portion of the data bases.

2. The daily data from plants contained in the 308 Data Base. A following subsection details the decisions involved in the selection of the plants included in the long-term Daily Data Base.

3. The original 308 data tape was used as the basis for the current specialized data bases. The following subsection describes the changes made to the original data and the parameters and terms used to profile the data.

The 308 Questionnaire was designed to collect information that would adequately describe and characterize the OCPS industry. Requested information related to such items as products manufactured, processes used, production rates, age, size, water consumption, wastewater generation, treatment technologies employed, and influent and effluent characteristics.

The responses varied in respect to completeness of response and detail of information. Some plants misinterpreted the units requested, did not give complete responses, provided data in units other than those requested, or otherwise responded in a manner which required either recalculation of the data, follow-up contacts for clarification, or in some cases rejection of the data. This may be explained in part by the fact that some companies simply did not keep records of information as was requested by the questionnaire, and consequently could not respond fully on all items of interest.

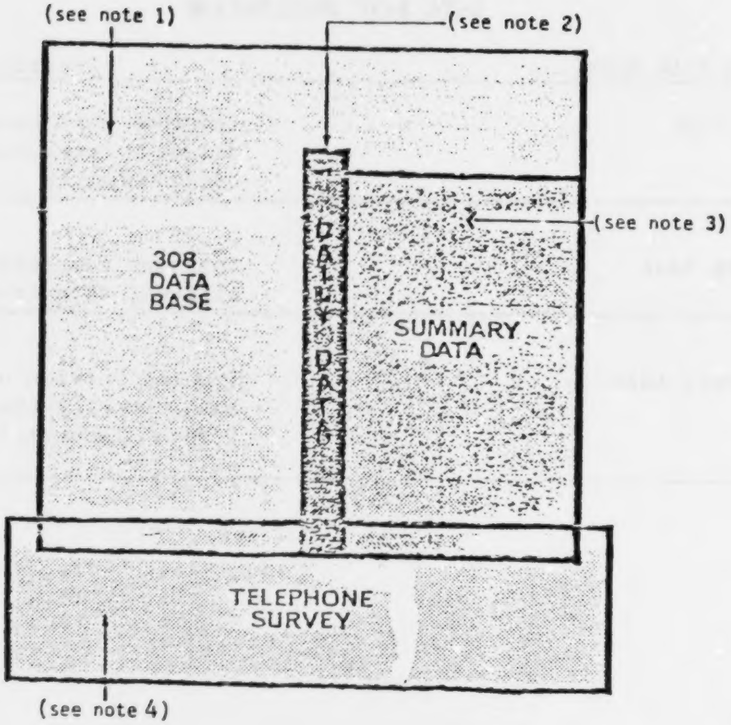
The data acquired from the questionnaire were necessary to assure that the industry was adequately described and to determine the need for subcategorization of the industry. Some specifics of the problems associated with the raw data and the corrective steps required for clarification are discussed in the following sections of this report.

The names applied to the data bases used in this report and a brief description of their contents are shown in Table 3-10 and Figure 3-9. These data base names will be used where the data bases are referred to in the text of this report.

TABLE 3-10

DATA BASE DESIGNATION

Data Base File Name	Description
308 Data Base	Original data base containing all data extracted from 308 Questionnaires
Daily Data Base	Contains long-term influent & effluent data from 50 plants
Summary Data Base	Updated version of 308 data base covering the 291 direct & zero discharge plants


(see note 1)
(see note 2)
(see note 3)
308 DATA BASE
DAILY DATA
SUMMARY DATA
TELEPHONE SURVEY
(see note 4)

NOTES:

(1) 308 Data Base contains information on 566 plants

(2) Daily Data Base contains information on 50 plants

(3) Summary Data Base contains information of 291 plants

(4) Telephone Survey Data Base contains information on 301 plants

FIGURE 3-9 - DATA OVERLAPS

In addition to the above data bases, there are numerous files of data that have been generated and stored in the computer to allow segregation and manipulation of special or selected data. These files contain such data as plant numbers, product/processes and treatment systems for indirect discharge plants, and plants rejected from the direct discharge and zero discharge (Summary) data base ("gray" plants) because the majority of each plant's production was not associated with the OCPS industry.

Final Data Base Development

The Summary Data Base is a corrected and updated version of the original data found in the 308 Data Base. Since this report covers only zero and direct dischargers, the 343 plants shown in the 308 Data Base as using those discharge modes were used as the initial list of plants for the Summary Data Base. A review of the information in the files of the remaining 223 indirect dischargers (including the responses from 1979 mailing to industry for data update) indicated that another 35 plants could no longer be classified as indirect dischargers. This brought the number of plants to be used in the Summary Data Base to 378. This left 188 plants marked as indirect dischargers in the 308 Data Base.

Data on product/processes, plant location and age, production, percent operating capacity, mode of discharge, treatment unit operations, influent and effluent wastewater flow and concentrations, age, and period of data collection were obtained from the original data printouts for each of the 378 plants in the total direct/zero discharge data base. The file for each plant was examined and the data were modified to reflect any corrections to the original data and to incorporate the plant's responses to the 1979 mailing. After these final corrections, the data were placed in a System 2000 Data Base Mangement System (DBMS) on EPA's UNIVAC Computers.

Examination of these data, however, pointed out problems which led to the deletion of 87 of the plants from the initial Summary Data Base. Forty-two of the deleted plants were rejected from the Summary Data Base because they were found to be indirect dischargers whose status had changed from direct or zero dischargers; eight of these indirect discharge plants also utilize some type of zero discharge technique. Eleven additional plants had data which were not representative of this industry. These included plants which have since been shut down, plants which have been sold or no longer make the products described in the BAT mailing, and one plant whose influent includes a large and unquantifiable amount of municipal sewage. Thirty-four plants were rejected because their products do not fall under the SIC codes being studied. These plants were divided into two groups. One group consists of 23 plants which clearly are not primarily in the SIC codes under study (e.g., refineries, paper mills, tall oil plants, welding gas plants, and plastics extrusion and compounding plants which do not polymerize on site). The other group consists of plants which make organics, but which are primarily inorganic plants. These plants typically have only one treatment system for all plant operations, with the wastewater from organics processes accounting for less than 10 percent of the total plant flow. This group of 11 rejected plants ("gray" plants) is segregated from the other group and may be studied separately or later with the rest of the organics industry. The final Summary Data Base, which after rejection of these 87 plants contains data from 291 plants, was entered into a System 2000 DBMS on the UNIVAC Computer.

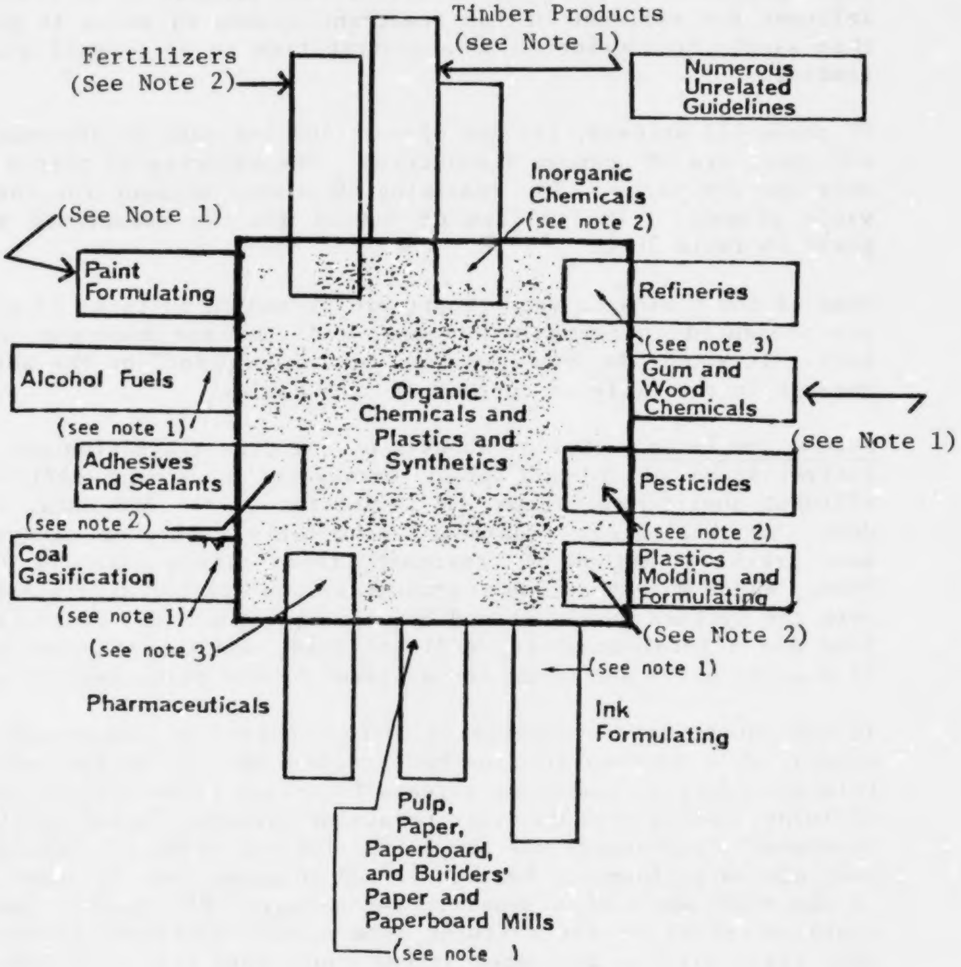
The final Summary Data Base contains detailed information on 291 plants which are direct dischargers or zero discharge/alternate disposal facilities. They were selected from the 566 plant data base (308 Data Base) for the reasons given previously. In addition to the 566 plants, some information is available on 243 plants from the EGD Telephone Survey, giving a total of 809 plants which are represented in some way in the data bases. This means that about 67 percent of approximately 1200 plants (or 40 percent of approximately 2100 plants estimated to be included in the OCPS industry by EPA) are directly covered in the combined data base.

SIC Code Applicability - As a result of the complexity of many plants in the chemical industry, several unrelated SIC codes may be applicable to a single plant. Consequently, the boundaries of the OCPS and related industries may not be sharply defined using SIC codes.

As a result there exists an overlapping of SIC code coverage in the Summary Data Base. Although the data included in the Summary Data Base are for the OCPS industries, some plants which manufacture primarily other materials, but also produce organic chemicals or plastics (e.g., production of alkyd or urethane resins in paint plants and formaldehyde production in adhesive plants), have been included in the Summary Data Base where the relevant development document specifically left such production for limitation by the OCPS regulations.

Additionally, where a separate wastewater treatment system exists for the OCPS portion of a mixed product (SIC code) plant, that plant's data were included in the Summary Data Base. Plants that specifically included manufacture of OCPS products in their regulations (petroleum refining, production of rosin resins in gum and wood chemicals, and pharmaceuticals) have been excluded from the Summary Data Base since this production is already covered by those regulations. Figure 3-10 presents these data base and industry guideline overlaps.

Stream/Plant Distinctions - The 291 plants in the Summary Data Base actually represent 377 different wastewater streams. A wastewater stream in this context is defined as a discrete disposal method used for the disposition of some of a plant's wastewater; dry processing and recycling of wastewater count as a stream each. For example, if a plant had two wastewater streams going to one activated sludge system, three to deep well injection, two processes which discharge wastewater untreated, and two dry processes (i.e., processes which neither use nor generate process contact water), it would be defined as having four waste streams: activated sludge, deep well, no treatment, and dry processing. However, if the two wastewater streams going to one activated sludge system were instead going to two separate activated sludge systems and had separate influent and effluent data for each, data for five streams would exist: two with activated sludge, one with deep well injection,


Timber Products
(see Note 1)
Fertilizers
(See Note 2)
Numerous
Unrelated
Guidelines
Inorganic
Chemicals
(see note 2)
(See Note 1)
Paint
Formulating
Refineries
(see note 3)
Alcohol Fuels
Gum and
Wood
Chemicals
(see Note 1)
Organic
Chemicals and
Plastics and
Synthetics
(see note 1)
Adhesives
and Sealants
Pesticides
(see note 2)
(see note 2)
Coal
Gasification
Plastics
Molding and
Formulating
(see note 1)
(See Note 2)
(see note 3)
(see note 1)
Pharmaceuticals
Ink
Formulating
Pulp,
Paper,
Paperboard,
and Builders'
Paper and
Paperboard Mills
(see note 1)

NOTES:

(1) No identified direct discharge Data Base overlap with organic chemicals and plastics and synthetic materials industries.

(2) Identified direct discharge Data Base overlap with organic chemicals and plastics and synthetic materials industries.

(3) Overlapping plants excluded from Data Base because organic chemical production is covered by categorical regulations through petrochemical and chemical synthesis subcategories in the appropriate industries.

FIGURE 3-10 - DATA BASE AND RELATED INDUSTRY GUIDELINES OVERLAP

one with no treatment, and one with dry processing. Separation of the plant processes in this manner allows each process to be linked with the influent and effluent of the treatment system to which it goes, rather than simply be considered as a contribution to an overall plant average loading.

Of these 377 streams, 212 are direct, 162 are zero or alternate disposal and three are of unknown disposition. The majority of plants (225) have only one discharge. The remaining 66 plants account for the other 152 waste streams. The tallies of plants and the associated streams are given in Table 3-11.

Some of the tables in this report are presented in terms of plants, some are presented in terms of streams, and some are presented in terms of both. It should be noted whether the word "plant" or the word "stream" appears in the title or content of each table.

Stream Combining - Early emphasis on the data evaluation was put on the determination of overall plant wastewater treatment efficiencies and effluent qualities. Since, by inspection of the 308 data, it was evident that biological treatment, especially activated sludge, was the most prevalent method of treatment, these plants were the first examined. Where more than one treatment system existed at a plant, the data over the systems were combined by calculating a total composite influent load and a total composite effluent load, and then the overall removal of a given pollutant parameter achieved by the plant was calculated.

In subsequent data evaluation efforts required to demonstrate the efficiency of a particular treatment technology, it became apparent that this procedure of combining streams to arrive at an overall influent and effluent loading over multiple treatment systems (including the "no treatment" discharges) was not suited for the study of individual treatment system performance because it led to gross over or under estimation of the efficiency of a specific technology. For example combining the characteristics of the effluent from a well operated biological treatment plant with an untreated stream could mask the effectiveness of the biological treatment plant.

To avoid the potential misrepresentation of treatment efficiencies, stream combination was abandoned except for five plants which utilize either dual biological or non-biological treatment. Each of these plants have multiple treatment systems for which the data presented were not detailed enough to allow separation of the data to evaluate the individual treatment system's performance. However, since the treatment technologies employed at each of the plants are similar within the multiple treatment installation at that plant, it is judged that no substantial data errors are generated by combining the streams and using the resultant data. For example, the data from a biological treatment system are not being combined with the results from a non-biological treatment system.

Finally, streams have been combined where product/processes could be specifically allocated to each stream. For example, if a plant sends its wastewater to north and south wastewater sewers without specifying

TABLE 3-11 - PLANTS AND THEIR ASSOCIATED STREAMS

	All	Direct Discharge	Zero Discharge	Unknown Discharge
For All Plants				
Total Number of Plants	291	195	94	2
Number of Plants with One Stream	225	156	67	2
Number of Plants with Multiple Streams	66	39	27	-
Number of Plants with Zero Discharge Streams	127	33	94	-
Number of Plants with Direct Discharge Streams	195	195	-	-
Number of Plants with Unknown Discharge Streams	3	-	-	3
For Plants Of Any Number Of Streams				
Total Number of Streams	377	251	124	-
Number of Direct Discharge Streams	212	212	-	-
Number of Zero Discharge Streams	162	38	124	-
Number of Unknown Discharge Streams	3	1	-	2
FOR PLANTS WITH MULTIPLE STREAMS				
Total Number of Streams	152	95	57	-
Number of Direct Discharge Streams	56	56	-	-
Number of Zero Discharge Streams	95	38	57	-
Number of Unknown Discharge Streams	1	1	-	-

which process has its wastewater sent to which sewer, and if both streams are treated with oil/water separation, it was assumed that those two separators had been combined.

Cooling Water - Often, effluent data for a plant is gathered after noncontact cooling water is mixed with the effluent from the treatment system. This dilution will decrease the apparent effluent concentration from the treatment processes. To factor out the effects of this dilution, each plant's effluent flow was reduced by the amount of the cooling water. The necessary assumption is that the total pounds of pollutant discharged are due to the effluent from the treatment system and no pollutants were contributed by the noncontact cooling water. If data on the cooling water were available, they were used for back calculation instead of assuming the water to be uncontaminated. The practice of reporting the plant effluent on the basis of total discharge (i.e., including commingled noncontact cooling water) is very common in this industry since most state regulatory agencies require the information on discharges to be based on total discharges and the quality thereof.

Of all the plants in the Summary Data Base, a total of 49 plants had cooling water commingled with the treatment plant discharge, thus requiring calculation to eliminate the diluting effects of the cooling water.

The assumption of uncontaminated cooling water will result in slight underestimates of treatment efficiency since the cooling water will not actually be completely free of contamination. It will also result in conservative (i.e., slightly high) estimates of effluent concentrations from the treatment facilities. However, it should be noted that cooling water can contribute relatively high TSS loadings, especially to the typically low strength plastics and synthetic materials wastewaters. If a cooling water stream was combined at the influent of a treatment system after the influent sample point, a composite influent stream was also developed as described above.

Offsite Treatment - One of the more confusing issues concerning the designation of treatment facility type was offsite treatment. Offsite treatment refers to that method used by a plant which discharges its wastewater to a privately or jointly owned treatment work. This designation was a source of confusion since some plants employing "offsite" treatment were originally regarded as indirect dischargers. Subsequent analysis determined that a plant discharging to a treatment work not owned by a governmental entity would not be covered by pretreatment standards for existing sources or pretreatment standards for new sources, and therefore would be covered by this study.

The offsite treatment plants were first differentiated from the 22 plants which use contract removal. Contract removal was considered to be removal in drums or trucks. Offsite-treated wastewater is defined as being wastewater piped directly to the treatment system handling the wastewater. Two more plants were removed because they had been purchased by the plant treating the wastewater. The product/processes and all other parameters associated with the purchased plants were combined with those from the parent plant.

After removing these two types of plants, there were still six plants which pumped their wastes either to a jointly or a privately owned treatment work. These six plants are described as utilizing offsite treatment.

Generic Processes - In addition to cataloging the products at each plant by product/process numbers, data was also sorted using generic chemical processes. For this effort, a list of 41 major generic processes was examined. General categories were also established for inorganic operations on organic chemicals, items which are called chemical processes but which really are not (cooling tower blowdown, etc.), products for which insufficient data exist to characterize the process, and products outside the SIC codes of interest to this report. A list of the generic codes used in the industry is shown in Table 3-9.

Each of the product/processes was then examined to determine its appropriate generic unit process. Where more than one generic process was required to characterize any particular product/process, engineering judgment was exercised to assign the step in the overall process most likely to generate wastewater.

Possible Sources of Inaccuracy - As is the case whenever a large compilation of diverse types of data are accumulated from a large number of varying sources, there are potential sources of error both in the data accumulated and in the interpretation of the data. Errors can arise because of questionnaire ambiguities and technical misinterpretation by the respondees. Some examples of these possible errors are:

1. The assumption that MGD was interpreted as million gallons per day, a commonly recognized term used by people in the wastewater field. However, in many responses "M" was interpreted as the Roman numeral for thousand, a practice also fairly common in many fields of engineering including those of the chemical industry.

2. Misinterpretation of treatment technology definition. This was most evident in the lack of consistency in referring to treatment processes which have subtle differences such as aerobic lagoon vs. aerated lagoon, the several options of activated sludge processes, and the use of colloquial or "house" names for such technologies as tertiary lagoons, polishing ponds and similar installations.

3. Failure of the respondents to fill in the questionnaire completely, or the submittal of conflicting or contradictory information.

To alleviate the effect of the possible errors, engineering judgments and calculations were made to determine reasonable values based on the data supplied, or follow-up contacts were made to plant personnel to clarify the data in question.

A source of inaccuracy in the data is the reporting of identical influent and effluent flows. This is a very common practice in industry where the effluent values for flow are reported, and for control of the waste treatment system influent flow is equated. Although this procedure may create errors by not accounting for slight amounts of water removed in the sludge, evaporation or other miscellaneous losses, the discrepancies introduced by equating influent and effluent flows are of more theoretical than practical interest and would be meaningful only for the most highly sophisticated material balance studies.

Another possible source of error is the reporting of net pollutant values. The NPDES permits at some plants allow them to offset the pollutant concentration of intake waters and allow them to report only the increase in pollution due to the plant. Many plants have this kind of permit and, since the 308 Questionnaire asked for pounds per day rather than concentration of pollutants, therefore reported the net increase in lbs/day used for their NPDES Discharge Monitoring Reports (DMRs) rather than the total amount of discharge. Unless specifically stated as such in the questionnaire response, plants reporting net BOD (or other parameter) discharges could be detected only where negative discharge loads were reported. Where detected, the values for net reporting were adjusted to the gross value prior to entry in the Summary Data Base. One plant (113) reported a negative value and three plants indicated the use of net values.

An additional potential error source could lie in the lack of differentiation between the filtered (soluble) BOD and unfiltered (total) BOD values. The customary practice in industry is to report total BOD since practially all reporting is normally done for permit purposes concerned with the total pollutant discharged. A review of the Summary and Daily Data Base plants showed only four plants which specified the method of reporting or analyzing for BOD: one plant specified unfiltered BOD results, another plant reported four months filtered and the remainder unfiltered, and two plants reported total BOD.

Another possible source of error in BOD values is the use of chlorination by some plants before the effluent sample point. Although there may be some reduction in BOD due to chlorination, the main effect of chlorination can be interference with the BOD test procedure. Residual chlorine in the wastewater sample can inhibit the growth of the bacterial seed used in the BOD test. This results in a BOD value lower than the true oxygen demand of the pollutants contained in the sample. However, since the effect of chlorine on BOD determinations is well known, the laboratory procedures (Standard Methods) employed in practically all wastewater laboratories provide methods for the removal of the chlorine before the BOD analyses are carried out. Examination of the data indicates that the respondents followed standard analytical procedures in BOD determinations.

The values for COD and TOC used in the Summary Data Base were collected from the data provided in the 308 Questionnaire responses. The values furnished could have been derived from laboratory determination, BOD/COD/TOC ratios, or values taken from literature. Since any source other than laboratory determinations or a properly derived and applied statistical correlation of parameter ratios may lead to erroneous conclusions, every effort was made to exclude COD and/or TOC values which could not be verified as being derived from acceptable procedures. Only one plant mentioned an empirical relationship but furnished no COD values.

These sources of error, if ignored, could seriously affect the quality of the data bases. Since these sources of error can and do exist in the accumulated raw data, a diligent review of the 308 Questionnaires and supplemental information was made in an effort to identify and either reject or correct discrepancies. Only after this review was data incorporated into the Summary Data Base.

Daily Data Base Development

One of the major purposes of this study is the development of long-term daily pollutant data. These data are required to derive variability factors which characterize wastewater treatment performance and provide the basis for derivation of proposed effluent limitations guidelines and standards. Hundreds of thousands of data points have been collected, analyzed, and entered into the computer.

The first effort at gathering daily data involved the BPT and BAT mailings. These questionnaires asked each plant for backup information to support the long-term pollutant values reported. Many plants submitted influent and effluent daily observations covering the time period of interest in the BPT questionnaire (January 1, 1976 to September 30, 1976). Additionally, there were some other conventional and nonconventional pollutant daily data in the files from the period of verification sampling. Some plants also submitted additional data with their responses to the 1979 mailing. Data from these three sources were examined and interpreted.

Approximately 50 plants were identified as those routinely taking influent and effluent daily observations of parameters of interest. These plants were contacted, and in many cases visited. The contacts usually resulted in accumulation of long-term (sometimes six years) influent and effluent data and detailed information on plant operations. Other data were obtained from various EPA offices which provided long term daily data for a total of 56 plants. Data from fifty of the plants were transcribed, keypunched, and loaded into the computer. Data from six of the plants were never used due to deficiencies in data.

After the data from plants were available on the computer, further investigation resulted in the reconsideration of some of the plants and/or data. However, the data from these flagged plants may be utilized in some of the statistical evaluations. Reasons for flagging of the transcribed daily data plants are:

1. Incomplete data (either influent or effluent data missing).
2. Major process changes during data collection period.
3. Dilution of effluent stream before sample point or influent stream after sample point which causes some difficulty in analyzing certain stream's data for each day.

4. The existence of conditions which indicate poor operation of a biological treatment system. Examples of these conditions include low MLSS for activated sludge plants, extreme carryover of suspended solids, and unconventional design parameters such as inadequate detention times.

A detailed acceptance/rejection analysis of Daily Data plants, for use in development of variability factors, is presented in Section VII.

The final Daily Data Base consists of data from 50 plants. These data are available in two forms on the UNIVAC computer. They are available in the units in which they were measured at the plant (some in mass per unit time and some in concentration) and in a file which has been preprocessed to a consistent set of flow (million gallons per day) and concentration (milligrams per liter) units. Each day's data consists of the plant number, the date and the influent and effluent parameters for flow BOD, COD, TSS, TOC, ammonia, oil and grease, phenol, chromium, pH, and temperature, where available.

Mode of Discharge

There are three basic discharge modes utilized by the industry: direct, indirect and zero or alternative disposal/discharge. Direct dischargers are plants which have a contaminated effluent, treated or untreated, which is discharged directly into a surface water. Plants with only noncontact cooling water or sanitary sewage effluents are not considered to be direct dischargers for purposes of this report. Indirect dischargers are plants which route their effluents to publicly owned treatment works (POTWs) and are therefore subject to pretreament standards. Discharge of wastewaters into the system of an adjoining manufacturing facility or to a treatment system not owned by a government entity is not considered indirect discharge, but is termed offsite treatment (see Offsite Treatment). Indirect dischargers are outside the scope of this report. Zero or alternative disposal/dischargers are plants which discharge no wastewater to surface streams or to POTWs. For the purposes of this report, these include plants which generate no wastewaters, plants which recycle contaminated waters, and plants which use some kind of alternate disposal technology (e.g., deep well injection, incineration or contractor removal).

Some plants with insufficient information to determine discharge mode were termed unknown dischargers (see Table 3-12).

The final Summary Data Base contains 291 plants, 195 of which are direct dischargers, 94 of which are zero or alternative disposal/dischargers, and two of which are unknown. No indirect dischargers are included. These 291 plants contain 377 waste streams, 212 of which are direct, 162 of which are zero or alternative disposal/dischargers, and three of which are unknown. The 195 direct discharge plants include 33 plants which also utilize zero or alternative disposal discharge techniques (see Table 3-12).

TABLE 3-12

NUMBER AND TYPES OF PLANTS AND STREAMS
IN THE DATA BASES

Summary Data Base (291 Plants)	Number of Plants				Number of Streams			
	All	Dir	Zero	Unk	All	Dir	Zero	Unk
All	291	195	94	2	377	212	162	3
Organic - Only	62	41	20	1	89	52	36	1
Plastic - Only	113	67	45	1	146	77	67	2
Organics/Plastics	116	87	29	-	142	83	59	-
Daily Data Base								
All	50	50	-	-	-	-	-	-
Organic - Only	6	6	-	-	-	-	-	-
Plastic - Only	17	17	-	-	-	-	-	-
Organics/Plastics	27	27	-	-	-	-	-	-
Informal Telephone Survey								
All	301							
Nonduplicated Plants	251							

Size

Although there are several possible ways to describe plant size, the 308 Questionnaire did not ask for sales, employment, or acreage data. Therefore, the only possible remaining description for size in the 308 Data Base is capacity and actual production. Since data available on the industry do not include capacity, and since one would not expect design capacity to determine the pollutant load, those numbers were not included in the Summary Data Base.

The Summary Data Base includes values for actual production as shown in the 308 Questionnaire and for percent of operating capacity being used in each plant. These data are presented on a stream basis as the total production of all products made at the plant whose wastewaters are directed to that stream and include production of all products contributing wastewater, including inorganics and other products not covered under the SIC codes of interest to this study. Table 3-13 presents the total production or organic chemicals and plastics in the 308 Data Base, the total OCPS production for industry determined by the Bureau of Census, and the Summary Data Base production values.

Age

Plant age could have an impact on pollutant loadings since water use, process technology, waste treatment technology, and plant maintenance techniques have vastly improved over the years since industry beginnings. Age was defined for purposes of this study as the year of installation of the oldest remaining unit at the plant. Table 3-14 presents the distribution of plant ages in the Summary and Daily Data Base. Plant ages range from two to 64 years, with most plants between 9 and 24 years old.

Products

The OCPS industry may be described in terms of the number and variety of products manufactured. This can be done by listing the manufactured products in a broad categorization such as "organics" and "plastics and synthetics" or by listing the separate products made at each plant.

The latter approach would provide useful information concerning the prediction of the presence of toxic pollutants at each plant but would not contribute significantly to the study of conventional and nonconventional pollutant parameters found in end-of-pipe wastewater. Therefore, the former method of using broad product categories was used for grouping data. Many of the tables in this section have included information based on plants which make only organic chemicals, plants which make only plastics, and plants which make both.

The final Summary Data Base contains 62 plants which are organic only producers, 113 plants which are plastic-only manufacturers, and 116 plants which make both (see Table 3-12). Approximately 1200 products exist in the 308 Data Base, while 31 percent (373) exist in the Summary Data Base.

TABLE 3-13

PRODUCTION COMPARISONS

	All Products (billion lb/yr)	Plastics (billion lb/yr)	Organics (billion lb/yr)
Total U. S. *	350	60	290
Total 308 Data Base	198.4 (57%)	44.6 (74%)	153.8 (53%)
Summary Data Base**			
All Streams	230	N/A	N/A
Direct Streams	190	N/A	N/A
Zero Streams	40	N/A	N/A

* per Table 3-1

** These data include manufacture of all products contributing to wastewater loading, including inorganics and other products not under study here.

N/A Data not collected in such a way as to make these numbers available

TABLE 3-14 NUMBER AND TYPES OF PLANTS AND STREAMS BY AGE

	Streams				Plants				
AGE	All	Dir	Zer.	Unk.	All	Dir	Zer.	Unk	Daily Data
2	1	1	-	-	1	1	-	-	-
3	6	4	1	1	5	4	1	-	1
4	8	6	2	-	8	6	2	-	2
5	4	1	3	-	4	1	3	-	-
6	8	4	4	-	7	4	3	-	-
7	6	3	3	-	4	2	2	-	1
8	7	2	5	-	7	3	4	-	-
9	14	11	3	-	13	10	3	-	4
10	14	8	6	-	13	7	6	-	-
11	16	8	8	-	12	7	5	-	1
12	14	9	5	-	12	7	5	-	1
13	10	8	2	-	9	7	2	-	2
14	11	4	6	1	10	5	4	1	3
15	20	16	3	1	18	16	1	1	4
16	9	6	3	-	8	6	2	-	2
17	10	5	5	-	10	5	5	-	1
18	13	7	6	-	12	7	5	-	1
19	14	7	7	-	14	7	7	-	1
20	10	5	5	-	9	4	5	-	2
21	13	7	6	-	11	7	4	-	2
22	11	6	5	-	9	4	5	-	-
23	10	8	2	-	8	7	1	-	3
24	10	7	3	-	9	7	2	-	1
25	7	5	2	-	7	5	2	-	-
26	4	2	2	-	4	3	1	-	-
27	4	4	-	-	4	4	-	-	1
28	5	4	1	-	5	4	1	-	1
29	5	2	3	-	5	2	3	-	-
30	4	2	2	-	4	2	2	-	1
31	2	-	2	-	2	-	2	-	1
32	8	5	3	-	5	4	1	-	1
33	6	5	1	-	6	5	1	-	1
34	3	3	-	-	3	3	-	-	1
35	1	1	-	-	1	1	-	-	-
36	2	2	-	-	2	2	-	-	-
39	4	4	-	-	4	4	-	-	2
40	6	5	1	-	5	5	-	-	1
41	1	1	-	-	1	1	-	-	-
42	1	1	-	-	1	1	-	-	-
43	3	2	1	-	3	2	1	-	-
44	0	0	-	-	0	0	-	-	1
46	1	1	-	-	1	1	-	-	1
50	1	1	-	-	1	1	-	-	-
51	2	2	-	-	2	2	-	-	2
52	1	1	-	-	1	1	-	-	-
56	1	1	-	-	1	1	-	-	-
64	1	-	1	-	1	-	1	-	-
0	65	15	50	-	9	7	2	-	4
TOTALS	377	212	162	3	291	195	94	2	50

Processes

Another important way to describe the data bases is in terms of processes. Process is a more significant description than product because one product may be made by numerous different processes, each of which uses different raw materials and reaction conditions. Data on products and on processes were taken in combinations which yield what are termed product/processes. A product/process is one product made by a particular process. For example, cyclohexanone manufacture by oxidation of cyclohexane is one product/process, and production of cyclohexanone (the same product) by dehydrogenation of cyclohexanol is a different product/process. Product/ process designations were given to all products and processes found in the data bases, including products not in the SIC codes of interest. There are approximately 2100 product/processes associated with the 1200 products in the 308 Data Base. The Summary Data Base contains 858 different product/processes. Attempting to relate each individual product/ process with its associated pollutant loading would be nearly impossible, not because the mechanics of such an effort would be difficult, but because the results would be of little value. This is true for two reasons. First, each product/process occurs an average of 2.1 times in the data base. This means that conclusions would have to be drawn on specific product/processes based on very little data. Second, each plant in the data base utilized an average of 6.2 product/processes and each stream contains an average of 4.8 product/processes. The fact that the average plant in the data bases makes so many products means that the end-of-pipe data collected on each plant will be a combination of the pollutant loads from all product/processes existing at that plant. Attempting to relate the end-of-pipe data to any one of the processes present cannot be done since all of the product/process data are for total end-of-pipe discharges.

Two methods have been used to make the study of processes more useful: complexity and generic product/processes.

Complexity - Plant complexity is a description of the variety of products and processes represented at each plant. In the OCPS study, complexity is defined as the number of product/processes available at each plant. The distribution of plants and streams among the various numbers of product/processes is indicated in Table 3-15. Plants range in complexity from one to 51 product/processes. Seventy-three percent of the streams have five or less product/processes going to each, while 45 percent of the plants have between twenty and thirty product/processes.

Generic Processes - To make the process information more meaningful, data were developed for generic process groups as described in "Generic Processes." Distributions of the streams among these generic groups are presented in Table 3-16. All of the generic groups in Table 3-9 are represented in the Summary Data Base.

TABLE 3-15 NUMBER AND TYPES OF PLANTS AND STREAMS BY PRODUCT/PROCESSES

	Streams				Plants				
No. of Product/ Processes	All	Dir	Zer	Unk	All	Dir	Zer	Unk.	Daily Data
1	65	31	33	1	42	21	20	1	3
2	43	27	15	1	26	15	11	-	7
3	55	30	24	1	22	14	8	-	10
4	25	19	6	-	8	5	3	-	4
5	26	19	7	-	5	3	2	-	2
6	17	10	7	-	3	2	1	-	1
7	8	6	2	-	2	2	-	-	1
8	12	8	4	-	1	1	-	-	2
9	8	6	2	-	1	1	-	-	3
10	8	5	3	-	7	5	2	-	1
11	10	8	2	-	10	8	2	-	1
12	3	3	-	-	3	3	-	-	1
13	4	2	2	-	2	1	1	-	-
14	4	4	-	-	4	4	-	-	4
15	4	2	2	-	4	2	2	-	1
16	3	3	-	-	3	3	-	-	1
17	2	1	1	-	2	1	1	-	-
18	3	3	-	-	3	3	-	-	1
20	2	2	-	-	4	4	-	-	1
21	2	2	-	-	11	6	5	-	-
22	2	2	-	-	13	12	1	-	1
23					27	13	13	1	-
24	1	1	-	-	13	10	3	-	-
25	1	1	-	-	23	18	5	-	-
26	2	2	-	-	16	10	6	-	1
27					6	5	1	-	-
28					11	8	3	-	-
29	1	1	-	-	9	6	3	-	-
31	1	1	-	-	1	1	-	-	-
33	1	1	-	-	1	1	-	-	1
34					1	1	-	-	-
39	1	-	1	-	1	-	1	-	-
41	1	1	-	-	1	1	-	-	1
45	1	1	-	-	1	1	-	-	1
51	1	1		-	1	1	-	-	-
Not Reported	60	9	51	-	3	3	-	-	1
TOTALS	377	212	162	3	291	195	94	2	50

TABLE 3-16

OCCURRENCES OF GENERIC PROCESSES

Generic Class* Codes	Occurrences in the Sum. Data Base	Occurrences in Direct Discharge Streams	Occurrences Zero Discharge Streams	Occurrences in Unknown Discharge Streams
A	63	48	15	–
B	99	85	14	–
C	139	102	37	–
D1	378	231	144	3
D2	140	121	19	–
E	51	46	5	–
F1	37	30	7	–
F2	16	14	2	–
G	117	92	25	–
H	71	57	14	–
I	6	5	1	–
I1	3	3	–	–
I2	17	17	–	–
J	2	2	–	–
J1	10	10	–	–
J2	19	15	4	–
K	26	22	4	–
L	24	24	–	–
M	35	32	3	–
N	5	3	2	–
O	42	32	10	–
P	35	33	2	–
Q	10	7	3	–
R	18	16	2	–
S	6	6	–	–
T	1	1	–	–
U	5	5	–	–
V	16	16	–	–
Z	6	6	–	–
12	20	17	3	–
13	1	–	1	–
14	9	9	–	–
15	27	23	4	–
16	6	3	3	–
17	8	8	–	–
18	4	3	1	–
19	1	1	–	–
2	48	43	5	–
20	8	8	–	–
21	4	2	2	–
22	1	1	–	–
23	18	17	1	–
24	9	2	7	–

TABLE 3-16 (Continued)

OCCURRENCES OF GENERIC PROCESSES

Generic Class* Codes	Occurrences in the Sum. Data Base	Occurrences in Direct Discharge Streams	Occurrences Zero Discharge Streams	Occurrences in Unknown Discharge Streams
3	203	150	52	1
4	12	6	6	-
5	63	54	9	-
6	20	16	4	-
7	2	2	-	-
8	4	4	-	-
9	1	1	-	-
TOTAL	1866	1451	411	4

* For description of codes see Table 3-9.

SECTION IV.

SUBCATEGORIZATION

INTRODUCTION

Sections 304(b)(1)(B) and 304(b)(4)(B) of the Clean Water Act require EPA to assess certain factors in establishing effluent limitations guidelines based on the best practicable control technology (BPT) and best conventional pollutant control technology (BCT). These factors include the age of equipment and facilities involved, the manufacturing process employed, the engineering aspects of the application of recommended control technologies including process changes and in-plant controls, non-water quality environmental impacts including energy requirements and other factors as determined by the Administrator.

To accommodate these factors, it may be necessary to divide a major industry into a number of unique and homogeneous groups or subcategories. This allows the establishment of uniform national effluent limitations guidelines and standards while at the same time accounting for the individual characteristics of different groups of facilities.

The factors considered in the subcategorization of the Organic Chemicals and Plastics and Synthetics Point Source Categories (OCPS) include:

1. Facility Size
2. Geographical Location
3. Age of Facility and Equipment
4. Raw Wastewater Characteristics
5. Treatability
6. Raw Materials
7. Manufacturing Product/Processes
8. Nonwater Quality Environmental Impacts
9. Energy Requirements

The impacts of these factors have been evaluated to determine if subcategorization is necessary or feasible. These evaluations are discussed in detail in the following sections.

STATISTICAL METHODOLOGY

Two major statistical techniques were used to determine an appropriate subcategorization scheme for the OCPS industry: the Spearman Rank Correlation [4-1] and the Terry-Hoeffding Test.[4-2] Both techniques are non-parametric, thus making the fewest assumptions about the nature of the underlying data.

The Spearman Rank Correlation was used to determine the existence of any relationships among the factors which must be considered for subcategorization of the OCPS industry. A detailed explanation of the Spearman Rank Correlation technique and an example of its use are presented in Appendix B.

The Terry-Hoeffding test was used to test whether two populations of plants differ in terms of median levels of a parameter of interest (e.g., median influent BOD concentration). If the test indicates that two groups of plants are different, then the groups could represent a basis for subcategorization. A detailed explanation of the Terry-Hoeffding test and an example of its use are presented in Appendix B.

TECHNICAL METHODOLOGY

All nine factors mentioned previously were examined for technical significance in the development of the proposed subcategorization scheme. However, in general, the proposed subcategorization is based primarily on significant differences in raw waste characteristics, since many of the other eight factors could not be examined in appropriate technical and statistical depth due to the intricacies of the data base. Therefore, variations in raw waste characteristics were utilized to evaluate the impact of the other eight factors on subcategorization. For example, the ideal data base for evaluating the need for subcategorization and the development of individual subcategories would include raw wastewater and final effluent pollutant data for facilities which employ only one generic manufacturing process or multiple product plants which segregate and treat each process raw waste stream separately. In this manner, each factor could be evaluated independently. Specifically, to evaluate the significance of facility size, the ideal data base would contain fifty or more plants using only one generic process and all varying in size (i.e., production rates of 10 kilograms per year to 1,000,000 kilograms per year). In addition, all 50 plants would be located in one geographic region and be of the same age. In this manner, the effects of size would not be masked or enhanced by the effects of geographic location or plant age. Therefore, to evaluate each factor ideally, the data base would need to contain plants that would allow isolation of each of the factors as described above for size.

However, the available information consists of historical data collected by individual companies primarily for the purpose of monitoring the performance of end-of-pipe wastewater treatment technology and compliance with NPDES permit limitations. The OCPS Industry is primarily comprised of multi-product/process, integrated facilities. Wastewaters generated from each product/process are collected in combined plant sewer systems and treated in one main treatment facility. Therefore, each plant's overall raw wastewater characteristics are affected by all of the production processes occurring at the site at one time. The effects of each production operation on the raw wastewater characteristics cannot be isolated accurately from all of the other site specific factors. Therefore, a combination of both technical and statistical methodologies had to be used to evaluate the significance of each of the subcategorization factors. In the methodology that was employed, the results of the technical analysis were compared to the results of the statistical efforts to determine the usefulness of each factor as a basis for subcategorization. The combined technical/statistical evaluations of the nine factors are presented below.

RAW WASTEWATER CHARACTERISTICS

Raw wastewater load (RWL) was selected as the dependent variable to be used to evaluate the significance of all of the subcategorization factors discussed in this section. RWL for the purposes of subcategorization is a measure of flow, BOD and TSS and was used as the basis for comparison to the other eight subcategorization factors.

Flow, for the purpose of this report, is measured in million gallons per day (MGD), and includes only process wastewater. This includes contact cooling waters, vacuum jet waters, wash waters, reaction media and contact steam. Wastewater flow does not include storm water, non-contact cooling water and sanitary wastewaters. Wastewater flow can be affected by facility size, efficiency of water use, methods of production (e.g., solvent or aqueous based), methods of cooling and vacuum generation, as well as other factors.

BOD is a measure of the wastewater's organic content (see Section V). Plants that use highly soluble organic materials, or use contact waters extensively, usually have higher BOD loadings than plants that use dry process techniques or solvent based reactions.

TSS is a measure of both organic and inorganic solid materials (see Section V). It is a measure of the insoluble phase of the wastewater. Higher TSS values can be associated with precipitation products, wash waters, contaminated storm water, as well as other sources.

MANUFACTURING PRODUCT/PROCESSES

Because this rulemaking involves the combination of two industries, (Organic Chemicals and Plastics & Synthetic Materials), an initial subcategorization involving the following broad industry segments was selected:

1. Plants manufacturing only plastics and synthetic materials
2. Plants manufacturing only organic chemicals
3. Plants manufacturing both organic chemicals and plastic and synthetic materials at the same facility.

Due to the nature of the raw materials and production processes, organic chemicals plants would be expected to have higher raw waste loads than plants manufacturing only plastics and synthetic materials, with combined organics and plastics plants lying between these two groups. This is confirmed in Figure 4-1, which shows the cumulative distribution of raw waste BOD for the three initial industry segments: Plastics Only, Organics Only, and Combined Plastics and Organics. Figure 4-2 presents the least squares fit of the data shown in Figure 4-1. As shown in these figures, the points generated from plotting the three cumulative distributions on log probability scale show the Plastics Only plants have considerably lower raw waste loads than the other two groups. This is further substantiated by the application of the Terry-Hoeffding Test for raw waste BOD for the groups Plastics Only and Not Plastics Only (combined groups 2 and 3). The test statistic T = 3.765 for a sample size of 123 yielded a probability level of zero. A level less than 0.05

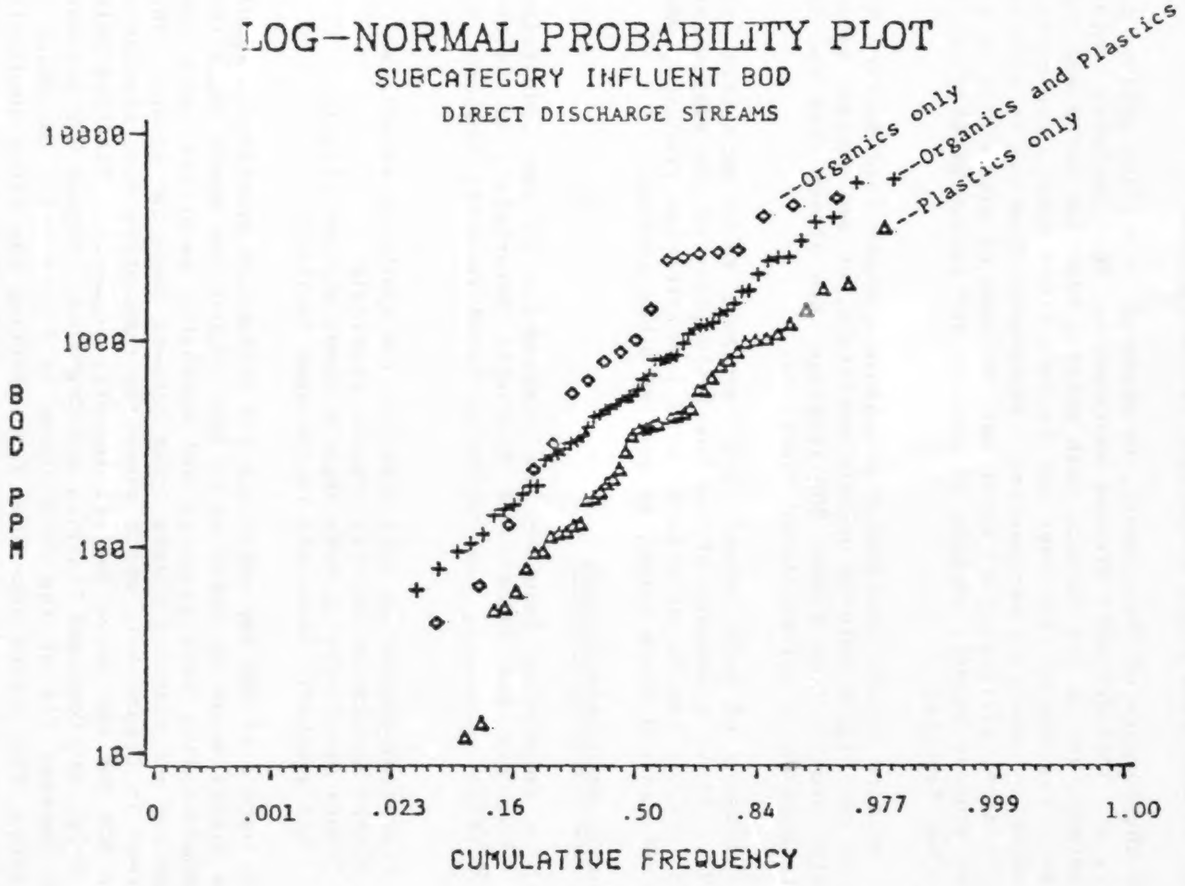


FIGURE 4-1 - PROBABILITY PLOT OF SUBCATEGORY INFLUENT BOD

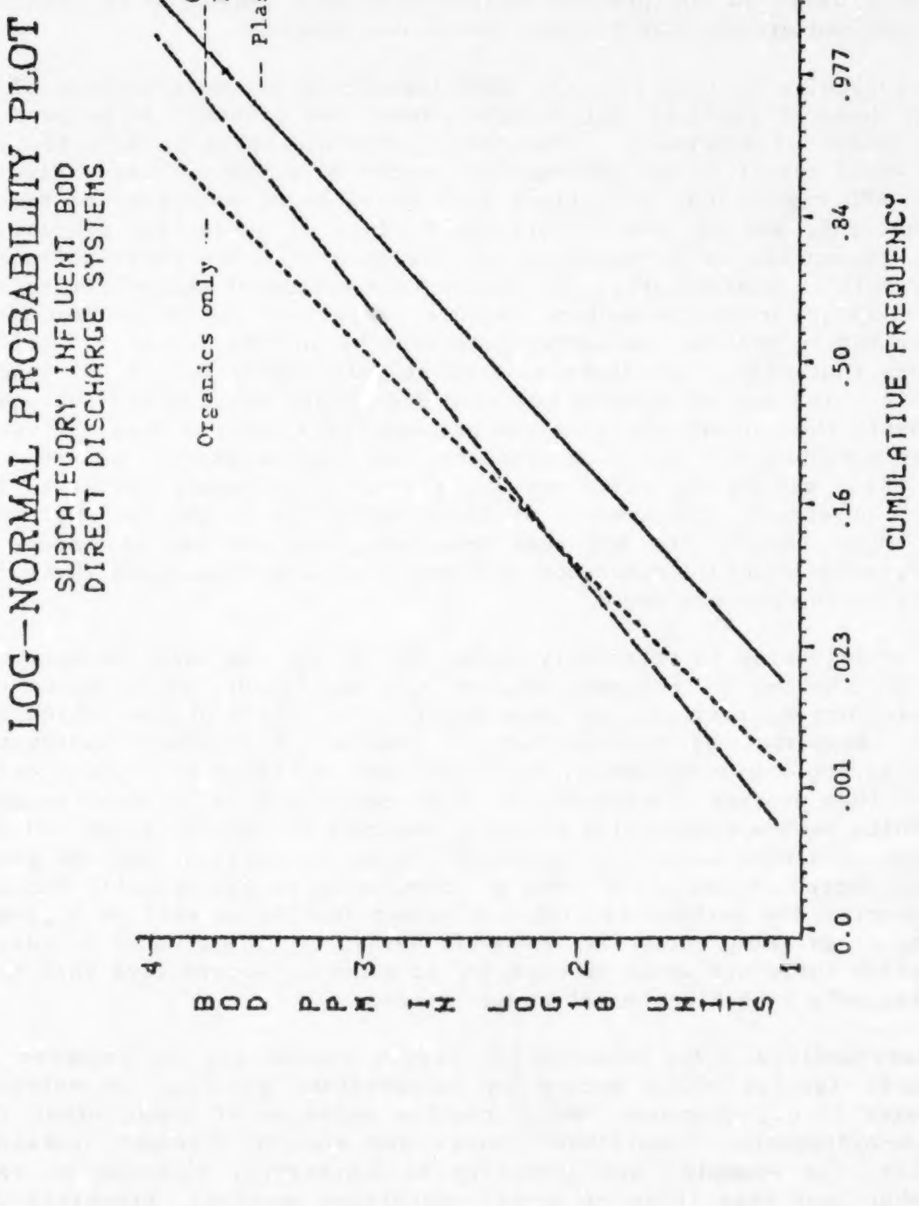


FIGURE 4-2 - LEAST SQUARES FIT OF FIGURE 4-1

is considered significant. Thus, Plastics Only is significantly different from the other two groups in terms of BOD. (There was no significant difference in the groups for TSS.)

The other two groups offer some statistical analysis problems. As shown in Figures 4-1 and 4-2, the Organics Only and Plastics and Organics groups yield cumulative curves which intersect, indicating an interrelationship between the groupings' organics contributions. Unfortunately, due to data deficiencies, it was not possible to proportion the individual organics and plastics raw waste contributions for combined organics and plastics producers by flow or production. As a result, another approach based on the product/process chemistry exhibited by plants in the combined groups (Not Plastics Only) was examined.

As detailed in Section III, the OCPS industry produces thousands of organic chemical products and in many cases, one product can be produced by a number of processes. Therefore, subcategorizing by specific product would result in an unmanageable number of subcategories. However, since BPT regulations will limit such broad based pollutant parameters as BOD, TSS, and pH, subcategorizing by type of production process and their tendencies to produce high or low quantities of these pollutants can result in a manageable, yet appropriate method of subcategorization. In general, certain production factors may affect the concentration of BOD or TSS in the raw wastewater generated by an OCPS industry facility. Factors that might contribute to a relatively higher BOD or TSS loading include: the use of aqueous reaction media that may require subsequent disposal, the general yield of the process (if a process does not retain a high percentage of reaction products, and instead product and reactant find their way to the waste stream, a relatively higher raw waste load may be observed), the absence of toxic materials in the raw wastewater that might inhibit the BOD test procedure, and the use of vacuum jet water, steam ejector condensate or contact cooling waters and their discharge to the process sewer.

Also contributing to relatively higher BOD or TSS raw waste characteristics is the use of raw materials or the manufacture of products that contain oxygen, nitrogen, or phosphorous. Generic processes which generate oxygenated by-products may be expected to produce wastewaters which are more biodegradable, and thus exert a higher biological oxygen demand than process wastewaters which do not. This is because enzymatic catabolic pathways generally follow a sequence of hydroxylation and subsequent oxidation to keto or carboxylic acid derivatives; and the greater the degree of oxidation (whether chemically or biologically induced) the shorter the pathway to ultimate biodegradation as well as a greater choice of existing catabolic enzymatic pathways. The generic process of oxidation therefore would be expected to generate wastewaters that exert a relatively high biochemical oxygen demand.

An intermediate 5-day biochemical oxygen demand may be expected for chemical species which occupy an intermediate position in metabolic pathways (i.e., compounds which require scission of bonds other than carbon-hydrogen). Substituted amines and similar nitrogen containing species, for example, are generally biodegradable, although at rates somewhat less than those of oxygen containing species. Processes that generate wastewaters containing nitrogen in a reduced form (amines, oximes, nitriles, etc.), or compounds that require scission of a carbon-oxygen bond prior to oxidative degradation (ethers), are predicted to exert an intermediate 5-day biochemical oxygen demand.

Other generic processes may be expected to generate wastewaters of relatively low biochemical oxygen demand for one of two reasons:

1. refractory chemical species predominate in the wastewater, or
2. relatively few chemical species are present in the wastewater

Generic processes such as nitration and sulfonation generate wastewaters of a refractory nature and, therefore, exert a low 5-day biochemical oxygen demand for the first reason. Other less refractory potential raw materials and products associated with the OCPS industry include aromatics, primary aliphatics, PCBs and halo-ethers. Generic processes producing high flow wastewaters that contain relatively few chemical species (for example, most polymerization processes) may also be expected to exert a low biochemical oxygen demand. Based on the presence or absence of species in industry wastewaters, and the generic process factors described above, it is reasonable to attempt to aggregate generic process wastewaters by their biodegradability on theoretical grounds. Table 4-1 summarizes expected 5-day biochemical oxygen demand by generic process group.

Type I includes those generic manufacturing processes expected to have high BOD values, whereas Type IV processes are expected to generate wastewaters lower in BOD. Type II and III processes complete the range of high to low BOD values.

The Terry-Hoeffding test was applied to the above product/process structure. As shown in Table 4-2, Type I vs. Not Type I was the only potential scheme which showed statistically signficant differences, with raw waste BOD showing the greatest difference (T = 2.251, P = 0.024). This suggested that the Not Plastics Only initial grouping be further divided into two subgroups:

- Plants manufacturing organic chemicals only and organic chemicals and plastics and synthetic materials in the same facility and which employ Type I generic chemical processes whether or not other Type processes are used at the facility (Not Plastics Only - Type I)

- Plants manufacturing organic chemicals only and organic chemicals and plastics and synthetic materials in the same facility and which do not employ Type I generic chemical processes (Not Plastics Only - Not Type I)

Upon further engineering analysis of the production process chemistry, it was believed that the oxidation generic product/process segment, which is part of Type I, contributed higher raw waste BOD loadings than any of the other processes. Thus, it was decided to further subcategorize by the presence or absence of the oxidation generic product/process. This decision was statistically confirmed by applying the Terry-

TABLE 4-1

EXPECTED 5-DAY BIOCHEMICAL OXYGEN DEMAND BY GENERIC PROCESS GROUP

TYPE I - High 5-Day Biochemical Oxygen Demand

- Oxidation
- Peroxidation
- Acid Cleavage
- Condensation
- Isomerization (maleic → fumaric acid)
- Esterification
- Hydroacetylation
- Hydration
- Alkoxylation
- Hydrolysis
- Carbonylation
- Hydrogenation (butyraldehyde → n-butanol)
- Neutralization

TYPE II - Intermediate 5-Day Biochemical Oxygen Demand

- Amination
- Ammonolysis
- Oximation
- Dehydration
- Ammoximdation
- Electrohydrodimerization
- Cyanation/Hydrocyanation
- Epoxidation (unsat'd esters)
- Etherification (alkycellulose)
- Polymerization (condensation)

TYPE III - Lower 5-Day Biochemical Oxygen Demand

- Alkylation (phenol → nonyl phenol)
- Hydrogenation (nitrobenzene → aniline)
- Dehydrogenation (isobutanol → acetone)
- Sulfonation
- Nitration

TYPE IV - Lowest 5-Day Biochemical Oxygen Demand

- Alkylation (phenol → nonyl phenol)
- Hydrodealkylation
- Isomerization
- Pyrolysis (steam)
- Cracking (catalytic)
- Dehydrogenation (ethyl benzene → styrene)
- Distillation
- Extractive distillation
- Crystallization/Distillation
- Polymerization (bulk & addition)
- Fiber production
- Halogenation
- Oxyhalogenation
- Hydrohalogenation
- Dehydrohalogenation (1,2-dicholorethane → vinyl Cl.)
- Chlorohydrination
- Phosgenation
- Extraction

TABLE 4-2

TERRY-HOEFFDING TEST
FOR NOT PLASTICS ONLY PLANTS

Raw Waste BOD

TYPES	TEST STATISTIC	SAMPLE SIZE	SIGNIFICANCE LEVEL
TYPE I vs. NOT TYPE I	T = 2.251	N = 74	P = .024
NOT TYPE I BUT TYPE II vs. NOT TYPE I OR TYPE II	T = .710	N = 11	P = .478

Raw Waste TSS

TYPES	TEST STATISTIC	SAMPLE SIZE	SIGNIFICANCE LEVEL
TYPE I vs. NOT TYPE I	T = .784	N = 47	P = .433
NOT TYPE I BUT TYPE II vs. NOT TYPE I OR TYPE II	T = .560	N = 13	P = .576

Note: See Table 4-1 for definition of Type I and II

Hoeffding Test to Type I With Oxidation versus Type I Without Oxidation. The test statistic was T = 2.706, sample size n = 63 and the significance level was P = 0.007. For TSS no significant differences were found.

The Terry-Hoeffding test was also used to investigate the applicability of the four subcategories to the parameters COD and TOC. The test results are shown in Table 4-3. For COD, significant differences were found between Plastics Only and Not Plastics Only plants, and between Type I and Not Type I plants in the Not Plastics Only group. For TOC, no significant differences were found. Based on these results it appears that the four subcategories are compatible with the COD and TOC data, and prior to considering the other factors listed previously, the initial subcategorization is:

1. Plants manufacturing only plastics and synthetic materials (Plastics Only).

2. Plants manufacturing organic chemicals only, organic chemicals and plastics and synthetic materials in the same facility, and other SIC code products which commingle their wastewater with the above OCPS wastewaters and employ Type I generic chemical processes including oxidation (Not Plastics Only - Type I With Oxidation).

3. Plants manufacturing organic chemicals only, organic chemicals and plastics and synthetic materials in the same facility, and other SIC code products which commingle their wastewater with the above OCPS wastewaters and employ Type I generic chemical processes, but do not include oxidation (Not Plastics Only - Type I Without Oxidation).

4. Plants manufacturing organic chemicals only, organic chemicals and plastic and synthetic materials in the same facility, and other SIC code products which commingle their wastewaters with the above OCPS wastewaters and employ Type II, III or IV generic chemical processes (Not Plastics Only - Not Type I).

FACILITY SIZE

Although sales volume, number of employees, area of plant site, plant capacity and production rate might logically be considered to define facility size, none of these factors completely describes size in a satisfactory manner. Section III discusses the elimination of each of these factors as an adequate definition of facility size.(*) Specifically, measuring a facility's size by using the sum of its production quantities does not account for all characteristics encompassed in plant size. For example, Plant A may have a relatively fixed market for a given product and therefore manufactures this product with dedicated equipment, 24 hours per day, 365 days per year. However, Plant B, which lists its production rate as identical to Plant A, may manufacture the same product on a specification basis in six to eight weekly campaigns

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(*) See Section III, pp. 21 to 28.

TABLE 4-3

TERRY-HOEFFDING TEST FOR SUBCATEGORIZATION BASED ON COD AND TOC

RAW WASTE COD

Category	Test Statistics	Sample Size	Significance Level
Plastics vs. Not Plastics Only	3.516	107	0.000
Not Plastics Only			
Type I vs. Not Type I	2.114	62	0.034
Type I and C vs. Type I and Not C*	1.347	49	0.178

RAW WASTE TOC

Category	Test Statistics	Sample Size	Significance Level
Plastics vs. Not Plastics Only	0.738	48	0.461
Not Plastics Only			
Type I vs. Not Type I	1.205	40	0.228
Type I and C vs. Type I and Not C*	0.576	32	0.564

* Type I w/oxidation vs. Type I w/o oxidation

per year. In addition, Plant A has invested R & D funds in this production process and has developed continuous production methods, while Plant B still utilizes batch production techniques. Therefore, although products are produced in the same annual quantities, Plant B will most likely have higher strength wastes due to less efficient production (lower yields) and much higher variability due to the campaign aspect of its operation. A statistical evaluation of size as defined by production also confirms that size is not a factor for subcategorization. In the Summary Data Base, the only production data available is on an individual waste stream basis. Table 4-4 presents the number of waste streams per facility size or production rate grouping for each of the initial subcategories. Table 4-5 and Figures 4-3 through 4-10 present correlations ranging from -0.3 to +0.19 for raw waste BOD and TSS in the initial subcategorization scheme. In all cases, the null hypothesis (Ho) is accepted; that is, raw waste BOD and TSS is independent of size as defined by production rate in pounds per day.

Therefore, there is no adequate method to define facility size, and it cannot be used as a technical basis for subcategorization. In addition, using production as an indication of facility size (because of data availability), as defined by production, was not a statistically significant factor for subcategorization.

GEOGRAPHICAL LOCATION

Companies in the OCPS industry usually locate their plants based on a number of factors. These include:

1. Sources of raw materials
2. Proximity of markets for products
3. Availability of an adequate water supply
4. Cheap sources of energy
5. Proximity to proper modes of transportation
6. Reasonably priced labor markets

In addition, a particular product/process may be located in an existing facility based on availability of certain types of equipment or land for expansion. Companies also locate their facilities based on the type of production involved. For example, specialty producers may be located closer to their major markets, whereas bulk producers may be centrally located to service a wide variety of markets. Also, a company may locate its plants based on its planned method of wastewater disposal. A company which has committed itself to zero discharge as its method of wastewater disposal has the ability to locate anywhere, while direct dischargers must locate near receiving waters, and indirect dischargers must locate in a city or town which has an adequate POTW capacity to treat OCPS wastewaters.

Because of the complexity and interrelationships of the factors outlined above affecting plant locations, no clear basis for subcategorization according to the plant location could be found. Therefore, location is not a basis for subcategorization of the OCPS industry.

TABLE 4-4

(DIRECT SYSTEMS) NUMBER OF WASTE STREAMS WITHIN PRODUCTION RATE RANGES

(#/day) Size	All Streams	Plastics Only	Not Plastics Type I & C*	Not Plastics Type I Not C**	Not Plastics Not Type I
1-9,999	1	0	0	1	0
10,000-49,999	5	2	0	2	1
50,000-99,999	7	5	1	1	0
100,000-249,999	21	15	2	1	3
250,000-449,999	27	16	5	3	3
450,000-599,999	20	8	7	2	3
600,000-999,999	28	14	7	4	3
1,000,000-1,999,999	33	12	7	6	8
2,000,000-4,999,999	29	1	13	8	7
Over 5,000,000	31	0	19	6	6
Missing	10	4	3	1	2
TOTAL	212	77	64	35	36

* Type I w/oxidation
** Type I w/o oxidation

TABLE 4-5

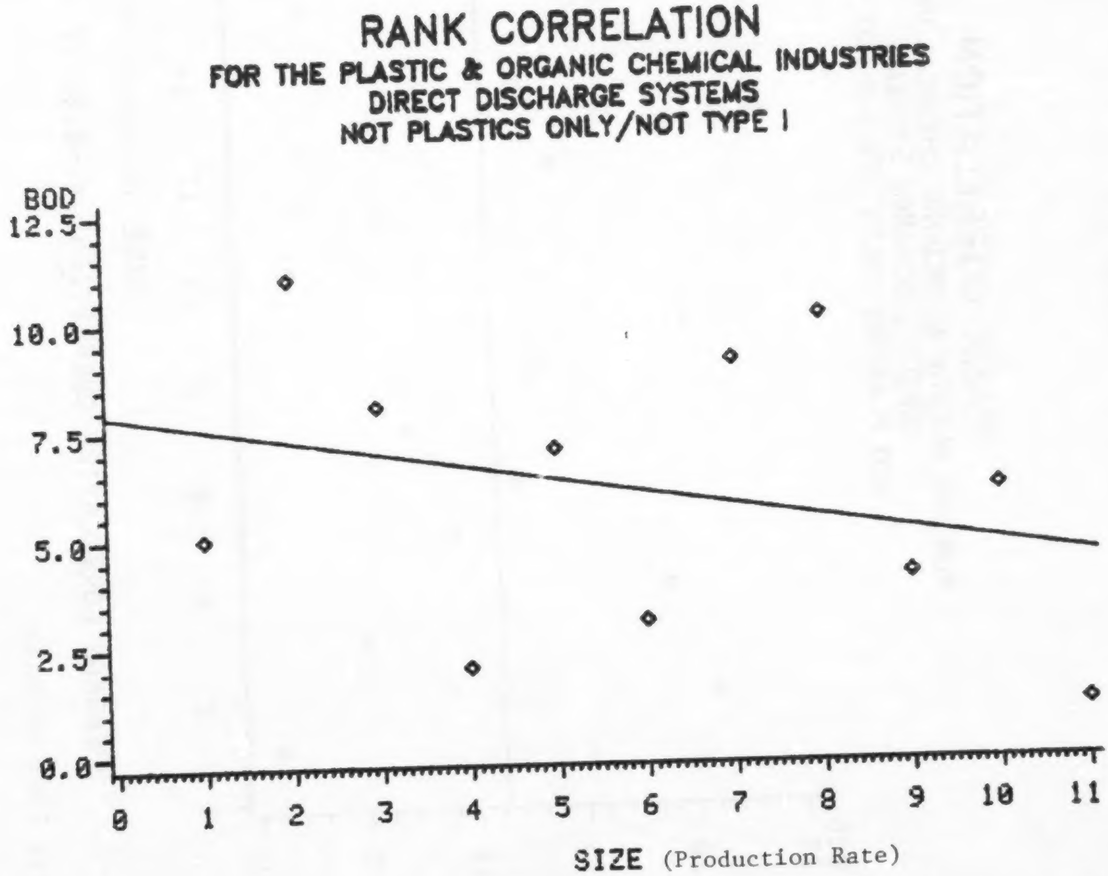
SPEARMAN CORRELATION COEFFICIENTS (R) FOR RAW WASTE BOD AND TSS vs. SIZE (Production Rate)

	All Plants	Plastics Only	Not Plastics Only		
			I w/oxidation	I w/o oxidation	No Group I
BOD	0.21 (0.02)	0.06 (N.S.)	-0.12 (N.S.)	-0.02 (N.S.)	-0.31 (N.S.)
TSS	0.02 (N.S.)	-0.00 (N.S.)	-0.13 (N.S.)	-0.42 (N.S.)	-0.20 (N.S.)

Note: Results of testing (Ho: C=0) are indicated as:

a) N.S. - Not significantly different from zero (P>.05)
b) <.01 - Significantly didfferent from zero (P<.01)
c) Actual probability (.01 <P<.05)

FIGURE 4-3



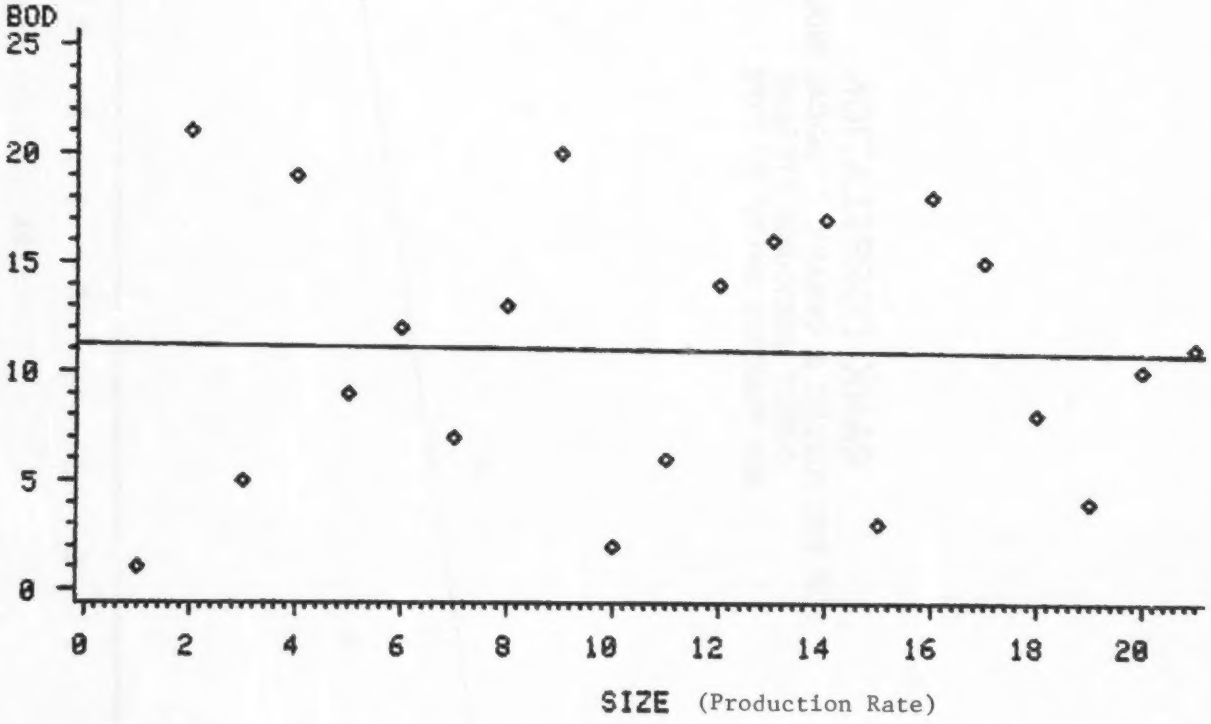
RANK CORRELATION

FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/NOT TYPE I

SPEARMAN CORRELATION COEFFICIENT = -0.31 (P = .36, N = 11)

FIGURE 4-4

RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/TYPE I & NOT C*

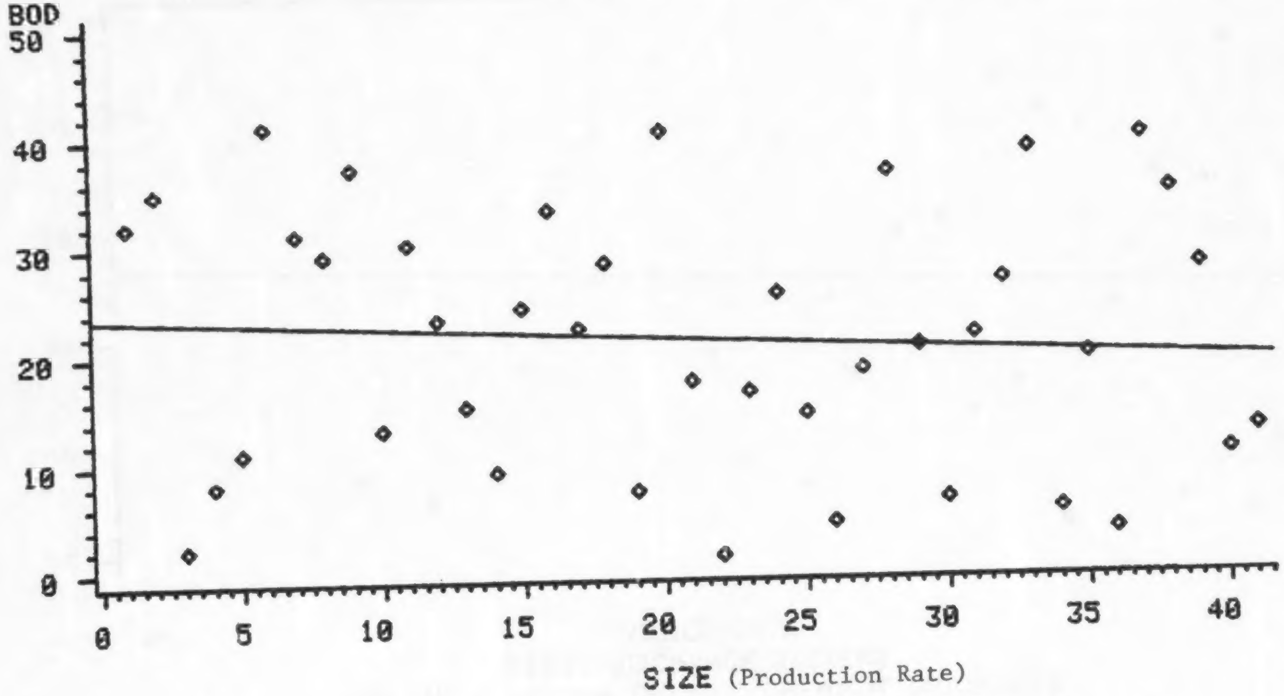


SPEARMAN CORRELATION COEFFICIENT = -0.02 (P = .92, N = 21)

* Type I w/o oxidation

FIGURE 4-5

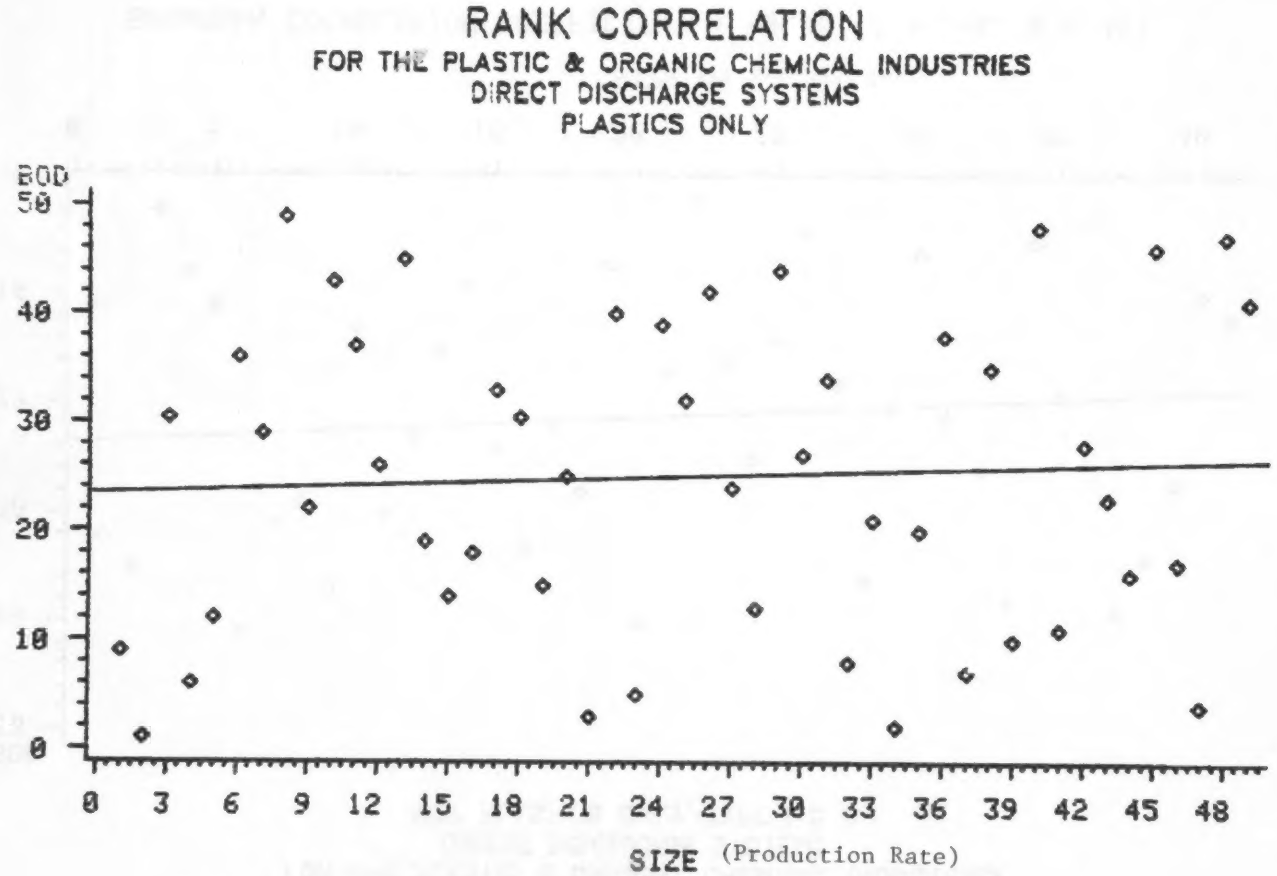
RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/TYPE I & C*



SPEARMAN CORRELATION COEFFICIENT = -0.12 (P = .46, N = 41)

* Type I w/oxidation

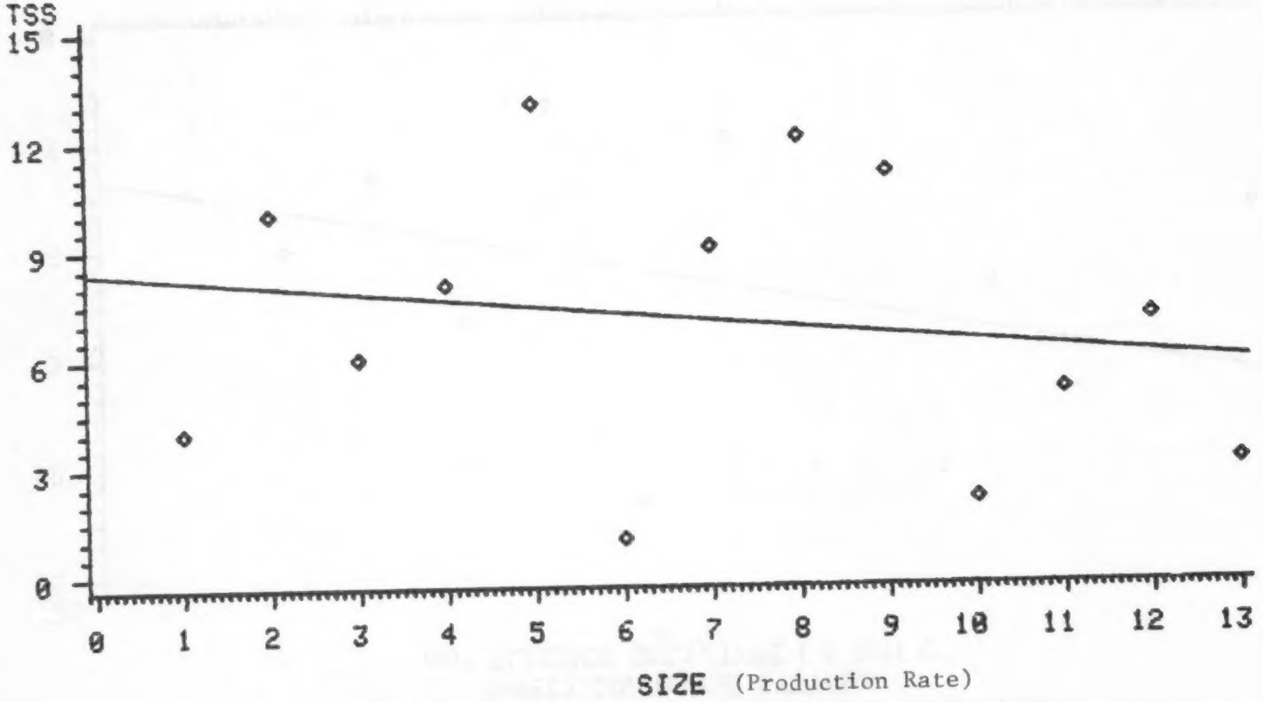
FIGURE 4-6



SPEARMAN CORRELATION COEFFICIENT = .06 (P = .67, N = 49)

FIGURE 4-7

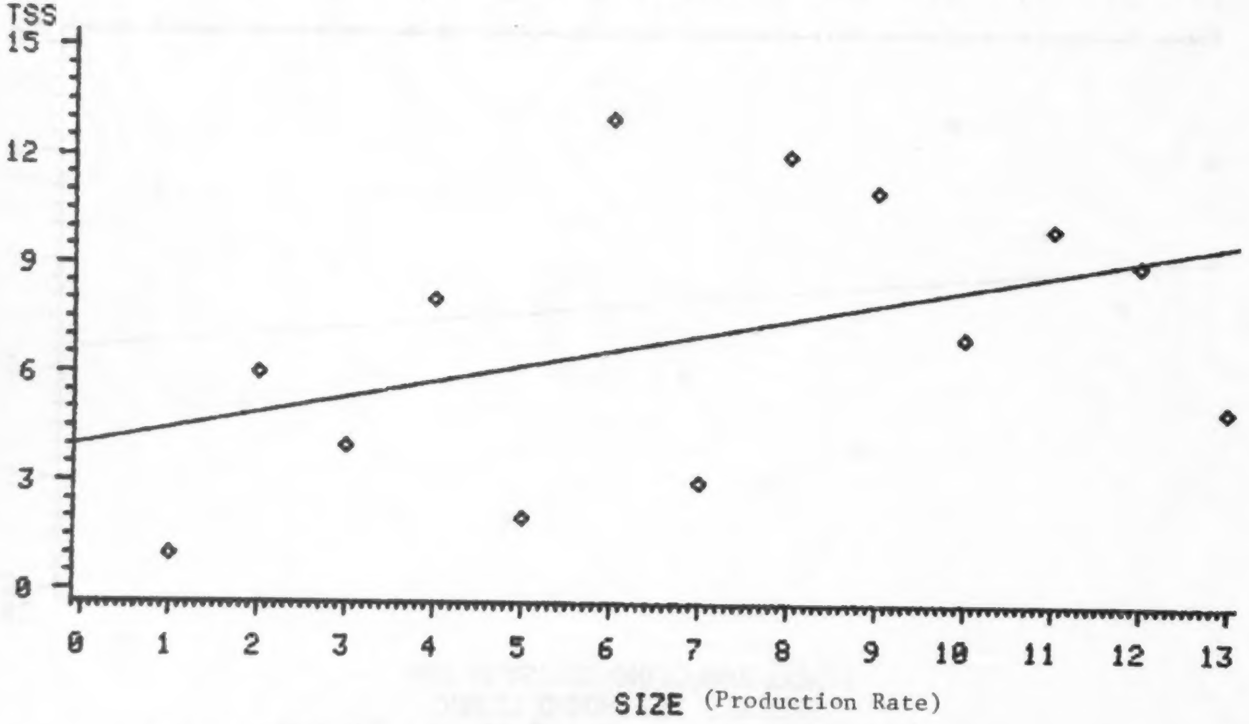
RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/NOT TYPE I



SPEARMAN CORRELATION COEFFICIENT = -0.20 (P = .52, N = 13)

FIGURE 4-8

RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/TYPE I & NOT C*



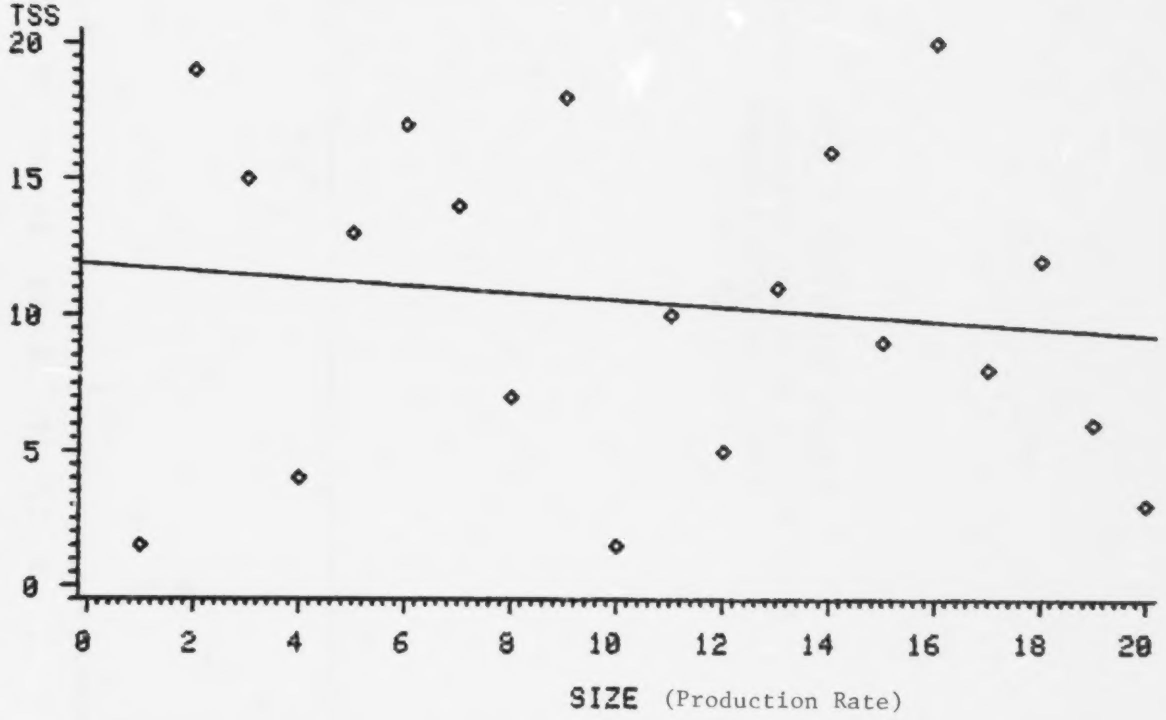
SPEARMAN CORRELATION COEFFICIENT = 0.42 (P = .15, N = 13)

* Type I w/o oxidation

FIGURE 4-9

RANK CORRELATION

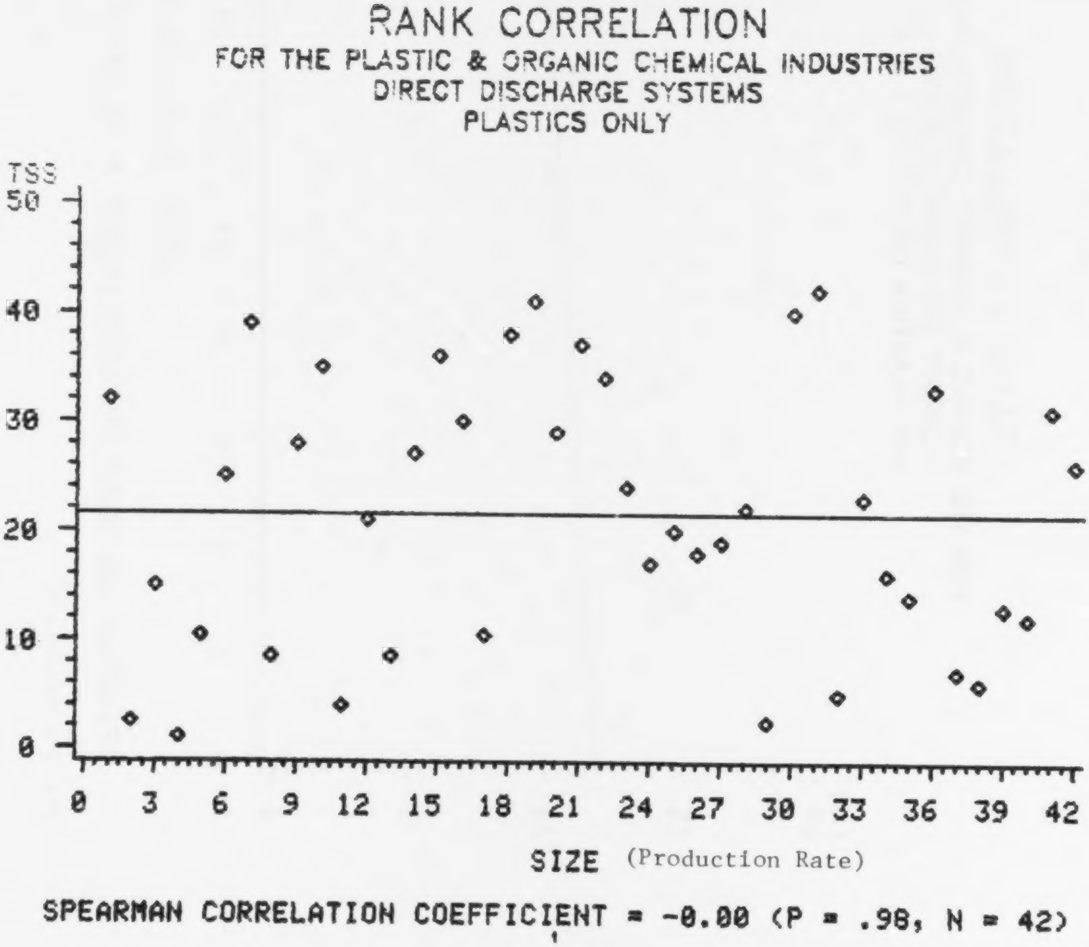
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/TYPE I & C*



SPEARMAN CORRELATION COEFFICIENT = -0.13 (P = .58, N = 20)

* Type I w/oxidation

FIGURE 4-10


RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
PLASTICS ONLY
TSS
50
40
30
20
10
0
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
SIZE (Production Rate)
SPEARMAN CORRELATION COEFFICIENT = -0.00 (P = .98, N = 42)

The effects of temperature, which is related to geographical location, are discussed in detail in Section VII, Control and Treatment Technology. It is concluded in Section VII that the effects of temperature are inconclusive.

AGE OF FACILITY AND EQUIPMENT

The age of an OCPS plant is difficult to accurately define. This is because production facilities are continually modified to meet production goals and to accommodate new product lines. Therefore, actual process equipment is generally modern (i.e., 0-15 years old). However, major building structures and plant sewers are not generally upgraded unless the plant expands significantly. Facility age, for the purposes of this report, and as reported in the 308 Questionnaire, is defined as the oldest process in operation at the site. Table 4-6 presents the number of waste streams per age grouping for each of the initial subcategories.

Older plants may use open sewers and drainage ditches to collect process wastewater. In addition, cooling waters, steam condensates, wash waters, and tank drainage waters are generally collected in these drains due to their convenience and lack of other collection alternatives. These ditches may run inside the process buildings as well as between manufacturing centers. Therefore, older facilities are likely to exhibit higher wastewater discharge flow rates than newer facilities. In addition, since the higher flows may result from the inclusion of relatively clean noncontact cooling waters and steam condensates as well as infiltration/inflow, raw wastewater concentrations may be lower due to dilution effects. Furthermore, recycle techniques and wastewater segregation efforts normally cannot be accomplished with existing piping systems, and would require the installation of new collection lines as well as the isolation of the existing collection ditches. However, due to water conservation measures as well as ground contamination control, many older plants are upgrading their collection systems. In addition, the energy crisis of recent years has caused many plants to upgrade their steam and cooling systems to make them more efficient.

Figures 4-11 through 4-18 present BOD and TSS raw waste rank correlations versus facility age for each of the initial subcategories. All rank correlations shown in Table 4-7 show no clear trend. The only apparent correlation appears for the Not Plastics Only-Type I With Oxidation group with a rank correlation of $R = -0.49$ and $P = <0.01$ for raw waste BOD and age. This negative correlation reinforces the argument that higher raw waste levels in newer plants can be attributed to more rigorous modern water conservation techniques. This is again supported by raw waste flow versus age rank correlations for the Not Plastics Only-Type I With Oxidation group, which shows a rank correlation of $R = 0.5$ and $P = 0.0001$. Thus, older plants within the same grouping tend to have higher flows which dilute the strength of their raw wastewaters. Therefore: (1) a plant's age for the purposes of regulation would be difficult to accurately measure, and (2) the relationship between facility age and RWL characteristics is greatly affected by many external factors, eliminating facility age as a feasible basis for subcategori-

TABLE 4-6

(DIRECT SYSTEMS)
NUMBER OF STREAMS PER AGE GROUP

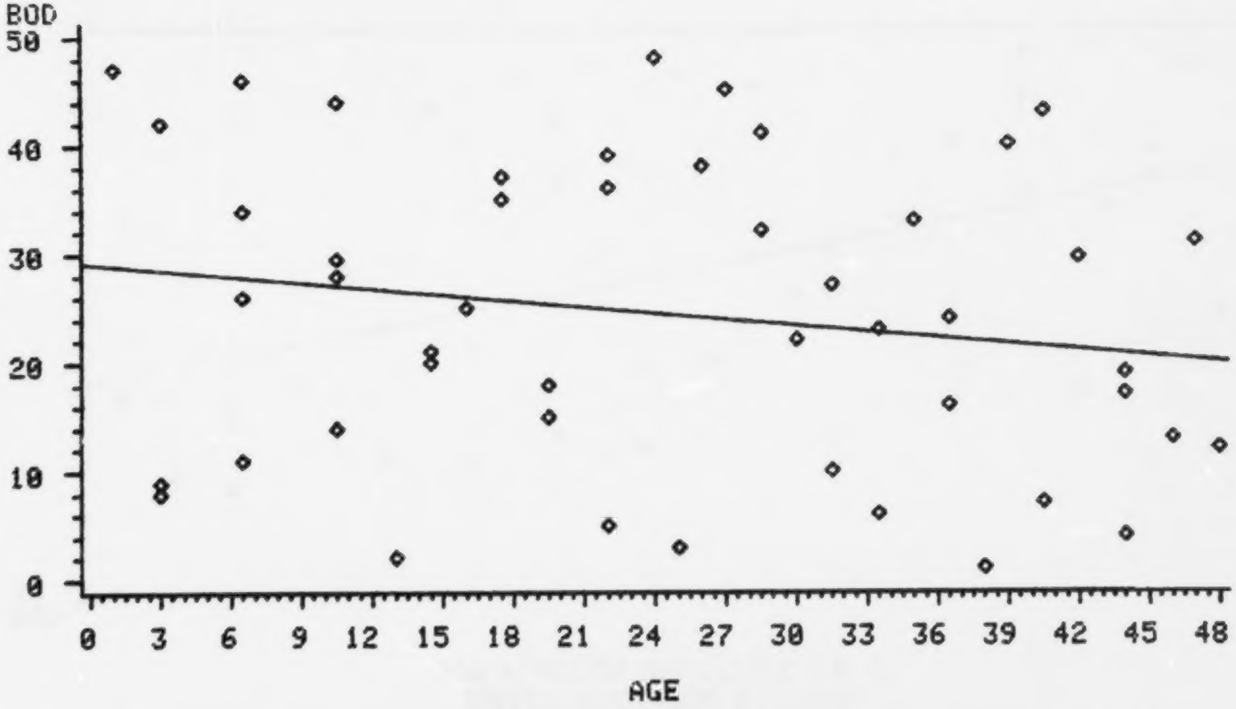
(Years) Age	All Streams	Plastics Only	Not Plastics Type I & C*	Not Plastics Type I Not C**	Not Plastics Not Type I
1-5	12	9	1	1	1
6-9	20	7	10	0	3
10-12	25	7	9	5	4
13-15	28	8	8	6	6
16-18	18	5	4	6	3
19-20	12	6	2	1	3
21-23	21	7	10	2	2
24-30	26	10	5	4	7
31-40	25	8	10	3	4
41-Over	10	4	2	2	2
Missing	15	6	3	5	1
TOTAL	212	77	64	35	36

* Type I w/Oxidation
II Type I w/o Oxidation

FIGURE 4-11

RANK CORRELATION

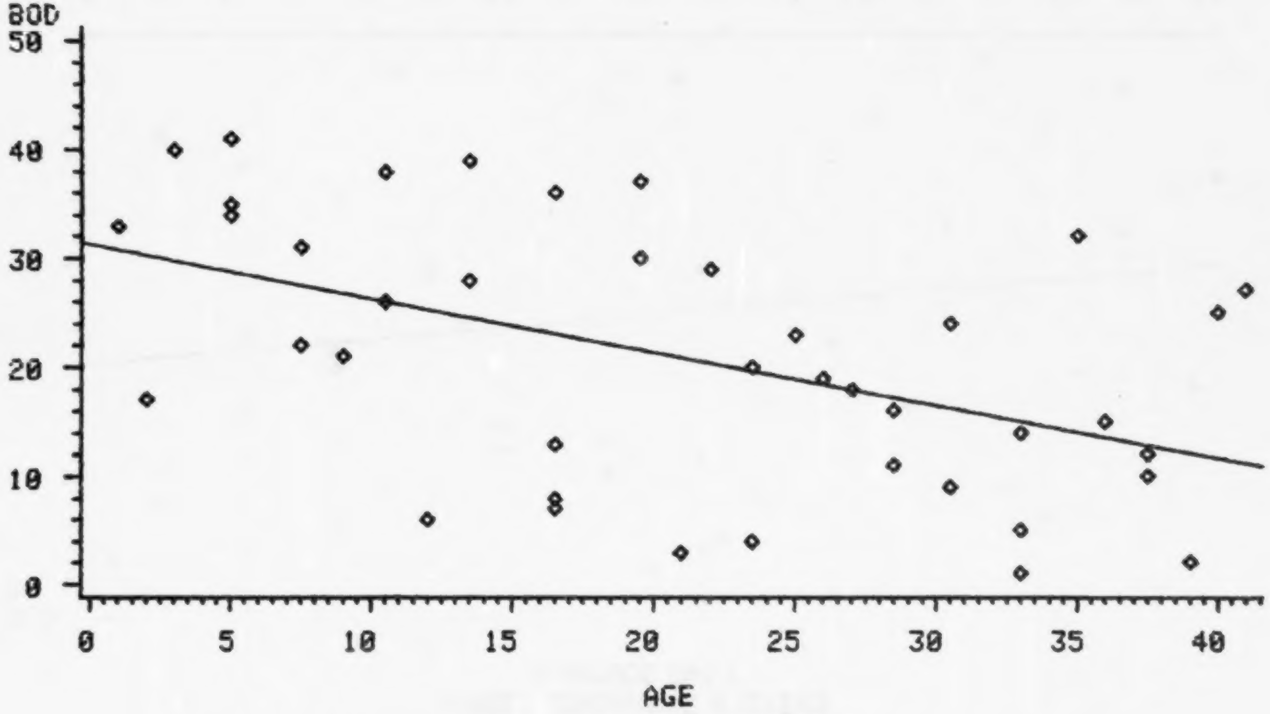
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
PLASTICS ONLY



SPEARMAN CORRELATION COEFFICIENT = -0.19 (P = .19, N = 48)

FIGURE 4-12

RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/TYPE I & C*



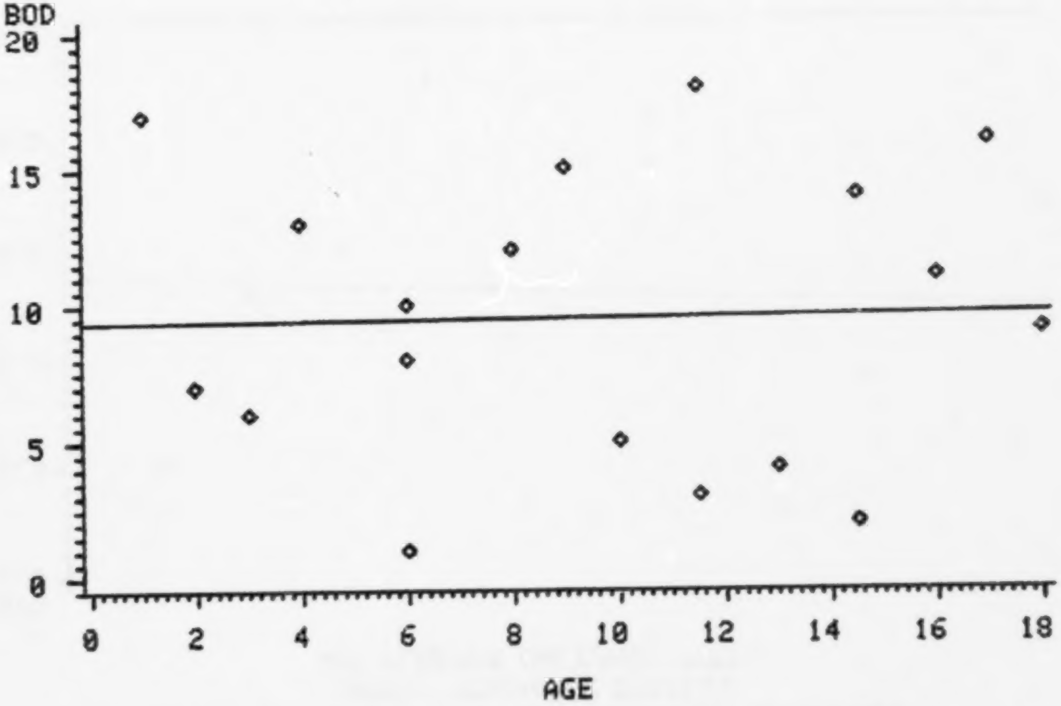
SPEARMAN CORRELATION COEFFICIENT = -0.49 (P = .00, N = 41)

* Type I w/oxidation

FIGURE 4-13

RANK CORRELATION

FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/TYPE I & NOT C*



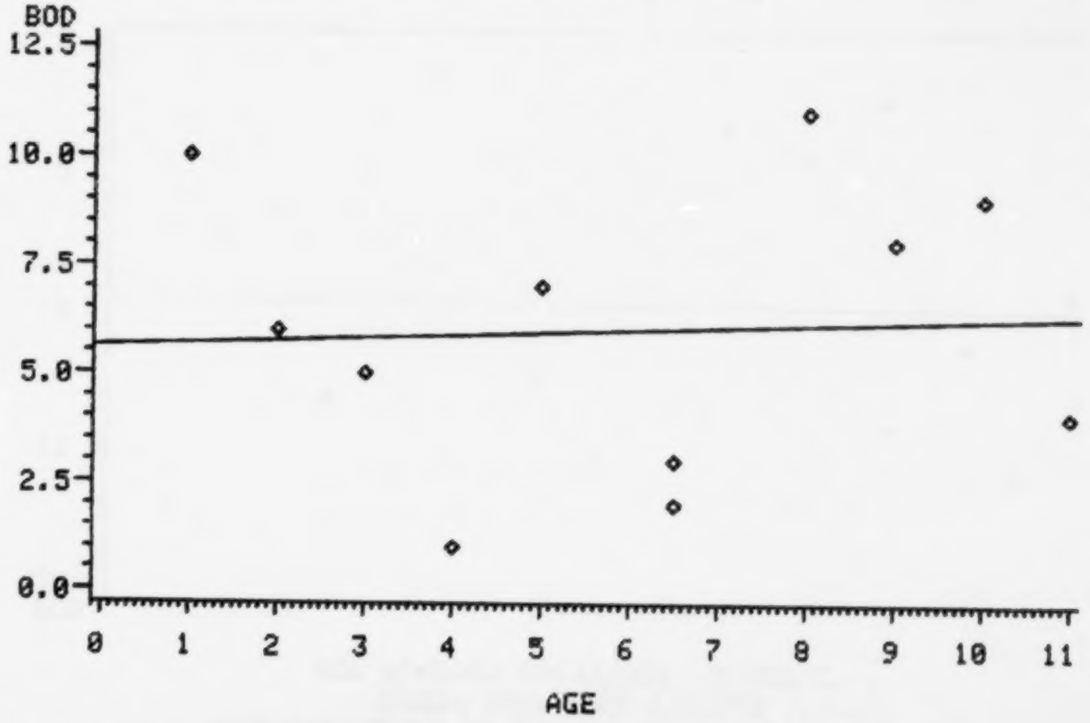
SPEARMAN CORRELATION COEFFICIENT = 0.01 (P = .96, N = 18)

* Type I w/o oxidation

FIGURE 4- 14

RANK CORRELATION

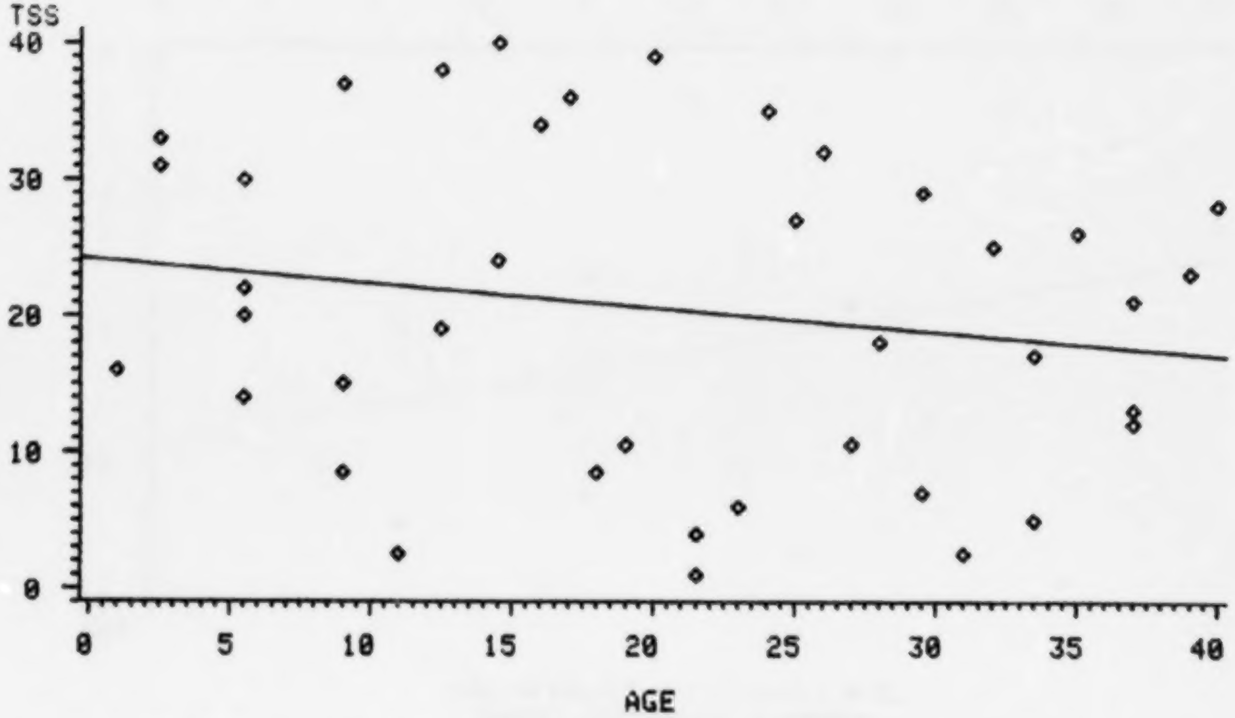
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/NOT TYPE I



SPEARMAN CORRELATION COEFFICIENT = 0.06 (P = .86, N = 11)

FIGURE 4-15

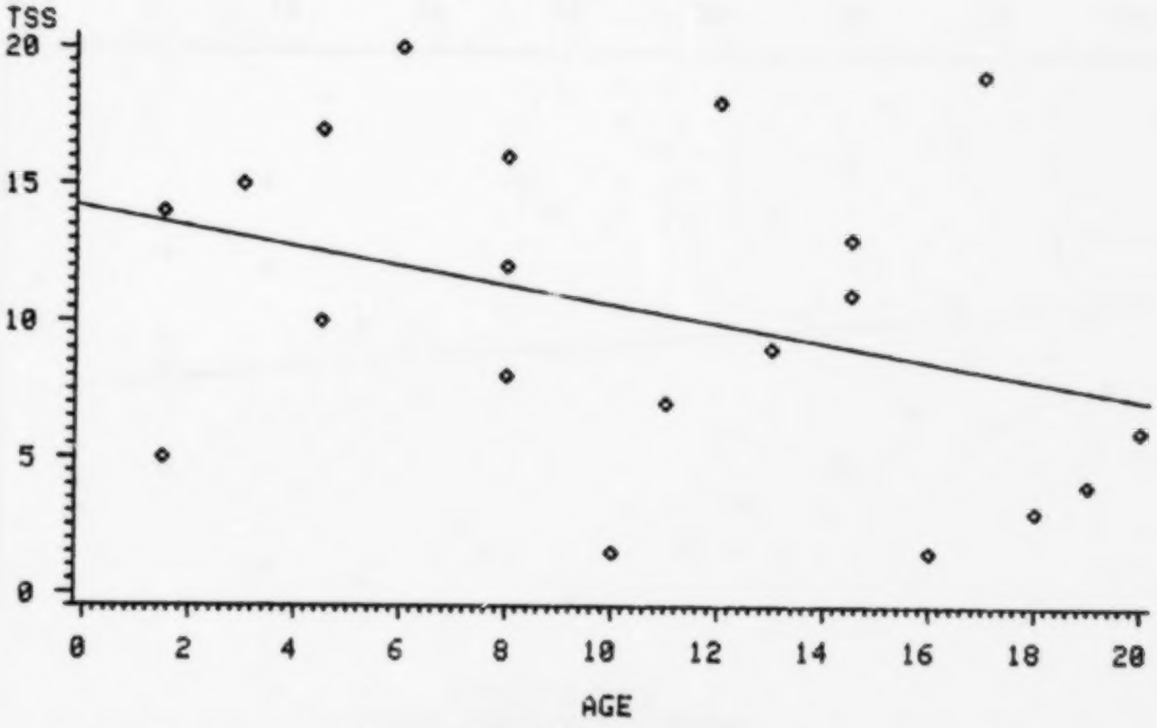
RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
PLASTICS ONLY



SPEARMAN CORRELATION COEFFICIENT = -0.18 (P = .25, N = 40)

FIGURE 4-16

RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/TYPE I & C*

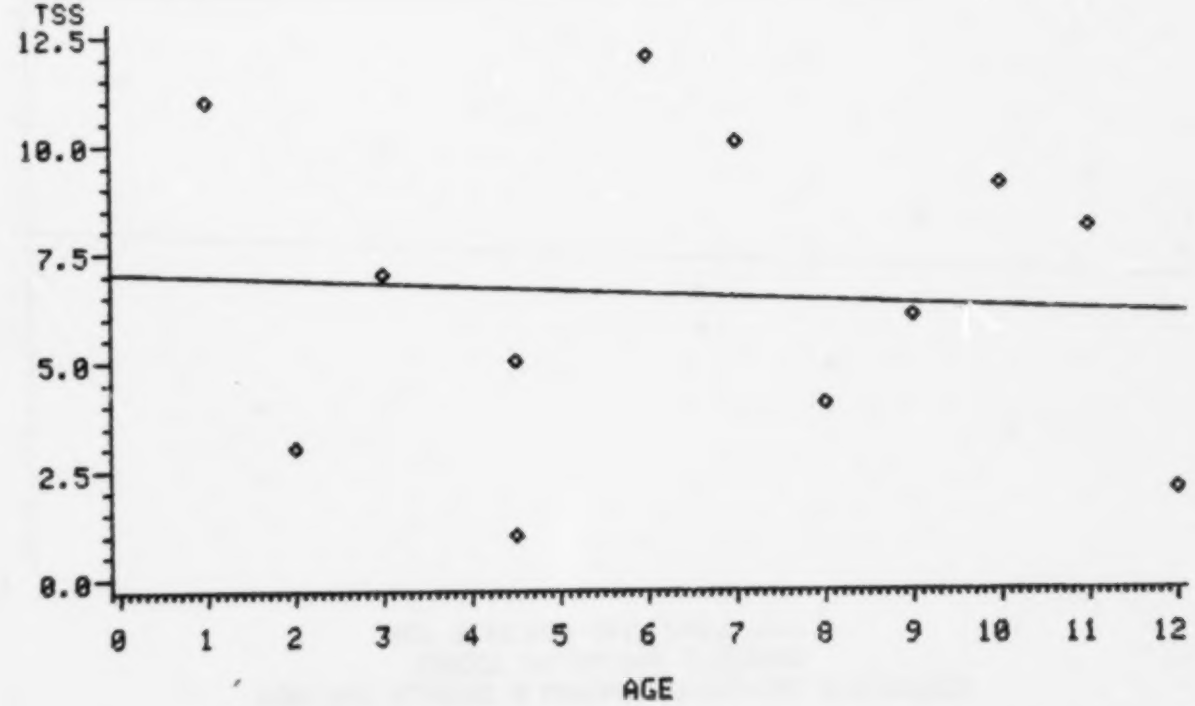


SPEARMAN CORRELATION COEFFICIENT = -0.35 (P = .13, N = 20)

* Type I w/oxidation

FIGURE 4-17

RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/TYPE I & NOT C *

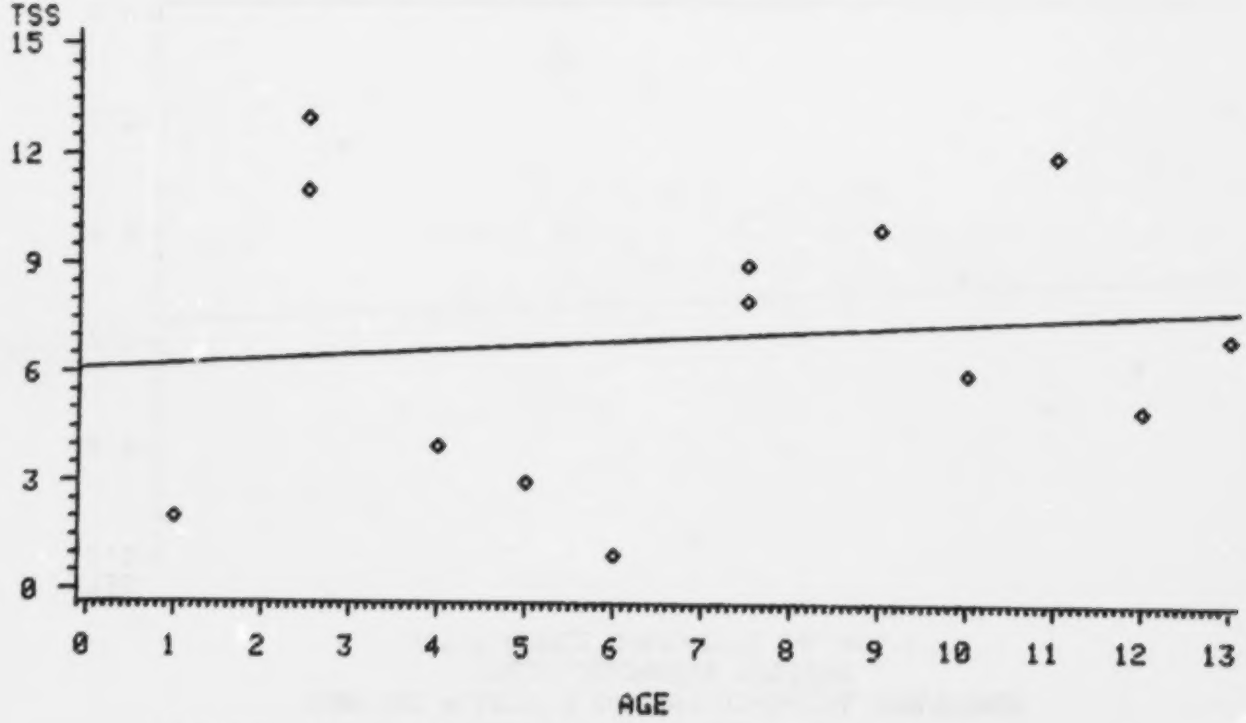


SPEARMAN CORRELATION COEFFICIENT = -0.08 (P = .80, N = 12)

* Type I w/o oxidation

FIGURE 4-18

RANK CORRELATION
FOR THE PLASTIC & ORGANIC CHEMICAL INDUSTRIES
DIRECT DISCHARGE SYSTEMS
NOT PLASTICS ONLY/NOT TYPE I



SPEARMAN CORRELATION COEFFICIENT = 0.12 (P = .69, N = 13)

TABLE 4-7

SPEARMAN CORRELATION COEFFICIENTS (R)
FOR RAW WASTE BOD AND TSS vs. AGE

	All Plants	Plastics Only	Not Plastics Only		
			I w/oxidation	I w/o oxidation	No Group I
BOD	-0.19 (0.04)	-0.19 (N.S.)	-0.49 .00	0.01 (N.S.)	0.06 (N.S.)
TSS	-0.13 (N.S.)	-0.18 (N.S.)	-0.35 (N.S.)	-0.08 (N.S.)	0.12 (N.S.)

Note: Results of testing (Ho: C=0) are indicated as:

a) N.S. - Not significantly different from zero (P>.05)
b) <.01 - Significantly different from zero (P<.01)
c) Actual probability (.01<P<.05)

zation. Nevertheless, because there is a negative correlation between RWL and age in the Not Plastics Only - Type I With Oxidation group, age and the subsequent impact of water usage may be important in this group. Therefore, evaluation of this phenomenon to accommodate these statistically significant factors based on water usage within this particular subcategory, is appropriate and is discussed in detail in Section VII.

RAW MATERIALS

Synthetic organic chemicals can be defined as derivative products of naturally occurring materials (petroleum, natural gas and coal) which have undergone at least one chemical reaction such as oxidation, hydrogenation, halogenation or alkylation. This definition, when applied to the larger number of potential starting materials and the host of chemical reactions which can be applied, leads to the possibility of many thousands of organic chemical compounds being produced by a potentially large number of basic processes having many variations. There are more than 25,000 commercial organic chemical products derived principally from petrochemical sources. These are produced from five major raw material classifications: methane, ethylene, propylene, C_4 hydrocarbons, and higher aliphatics and aromatics. This major raw materials list can be expanded by further defining the aromatics to include benzene, toluene and xylene. These raw materials are derived from natural gas and petroleum, although a small portion of the aromatics are derived from coal. Currently, approximately 90 percent by weight of the organic chemicals used in the world are derived from petroleum or natural gas. Other sources of raw materials are coal and some naturally-occuring renewable material of which fats, oils and carbohydrates are the most important. The third source also includes more obscure natural products (consisting of small quantities of very specialized chemicals) which contribute to highly specialized segments of the industry.

Regardless of the relatively limited number of basic raw materials utilized by the organic chemicals industry, process technologies lead to the formation of a wide variety of products and intermediates, many of which can be produced from more than one basic raw material either as a primary reaction product or as a by-product. Furthermore, primary reaction products are frequently processed to other chemicals which categorize the primary product from one process as the raw material for a subsequent process.

Delineation between raw materials and products is nebulous at best, since the product from one manufacturer can be the raw material for another manufacturer. This lack of distinction is more pronounced as the process approaches the ultimate end product, which is normally the fabrication or consumer stage. Also, many products/intermediates can be made from more than one raw material. Frequently, there are alternate processes by which a product can be made from the same basic raw material.

Another characteristic of the OCPS industry which makes subcategorization by raw material difficult is the high degree of integration in manufacturing units. Since the bulk of the basic raw materials are derived from petroleum or natural gas, many of the organic chemical manufacturing plants are either incorporated into or continguous to petroleum refineries, and may formulate a product at almost any point in a process from any or all of the basic raw materials. Normally, relatively few organic manufacturing facilities are single product/process plants unless the final product is near the fabrication or consumer product stage.

Because of the integrated complexity of the largest (by weight) single segment of the organics industry (petrochemicals), it may be concluded that subcategorization by raw materials is not feasible for the following reasons:

1. The organic chemicals industry is made up primarily of chemical complexes of various sizes and complexity.

2. Very little, if any, of the total production is represented by single raw material plants.

3. The raw materials used by a plant can be varied widely over short time spans.

4. The conventional and nonconventional wastewater pollutant parameter data gathered for this study were not collected on a raw materials orientation, but rather represent the mixed end-of-pipe plant wastewaters.

TREATABILITY

Treatability of OCPS wastewaters is discussed in great detail in Section VII. The treatability of a given wastewater is affected by the presence of inhibitory materials (toxics); availability of alternative disposal methods; and pollutant concentrations in, and variability of, the RWL. However, all of these factors can be mitigated by sound waste management, treatment technology design, and operating practices. Examples of these are:

- The presence of toxic materials in the wastewater can be controlled by in-plant treatment methods. Technologies such as steam stripping, metals precipitation, activated carbon, reverse osmosis, etc. can eliminate the presence of materials in a plant's wastewater which may inhibit or upset biological treatment systems.

- Although many plants utilize deep well injection for disposal of highly toxic wastes to avoid treatment system upsets, other alternative disposal techniques such as contract hauling and incineration are available to facilities which cannot utilize deep well disposal. In addition, stricter groundwater regulations may eliminate the option of deep well disposal for some plants, or make it uneconomical for others, forcing facilities to look more closely at these other options.

- RWL variability can easily be controlled by the use of equalization basins. In some plants, "at process" storage and equalization is used to meter specific process wastewaters, on a controlled basis, into the plant's wastewater treatment system.

- Raw waste concentrations can be reduced with roughing biological filters or with the use of two-stage biological treatment systems. These techniques are discussed in more detail in Section VII.

OCPS wastewaters can be treated by either physical-chemical or biological methods, depending on the pollutant to be removed. Also, depending on the specific composition of the wastewater, any pollutant may be removed to a greater or lesser degree by a technology not designed for removal of this pollutant. For example, a physical-chemical treatment system designed to remove suspended solids will also remove a portion of the BOD of a wastewater if the solids removed are organic and biodegradable. It is common in the OCPS industry to use a combination of technologies adapted to the individual wastewater stream to achieve desired results. These concepts are discussed in detail in Section VII.

In general, the percent removals of BOD and TSS are consistent across all initial subcategories. It is also possible for plants in all initial subcategories to achieve high percent removals (greater than 95%) for both BOD and TSS (data supporting these removals are presented and discussed in Section VII). Therefore, based on the consistency of these removal data and the ability of plants in all initial subcategories to achieve high removals of pollutants, it is concluded that subcategorization based on treatability is not justified.

ENERGY AND NON-WATER QUALITY ASPECTS

Energy and non-water quality aspects include the following:

1. Sludge production
2. Air pollution derived from wastewater generation and treatment
3. Energy consumption due to wastewater generation and treatment
4. Noise from wastewater treatment

The basic treatment step, used by virtually all plants in all subcategories that generate raw wastes containing basically BOD and TSS, is biological treatment. Therefore, the generation of sludges, air pollution, noise and the consumption of energy will be homogeneous across the industry. However, the levels of these factors will relate to the volume of wastewater treated and their associated pollutant loads. Since the volumes of wastewater generated and the RWL from each pollutant were considered in earlier sections, it is believed that all energy and non-water quality aspects have been adequately addressed in the proposed subcategorization scheme.

SUMMARY - SUBCATEGORIZATION

Based on the preceding technical and statistical evaluation of the OCPS industry, four subcategories have been established. These subcategories are as follows:

Subcategory 1 - Plastics Only

Discharges resulting from the manufacture of plastics and synthetic fibers only.

Subcategory 2 - Oxidation

Discharges resulting from the manufacture of organic chemicals only, or both organic chemicals and plastics and synthetic fibers, that include wastewater from the oxidation process.

Subcategory 3 - Type I

Discharges resulting from the manufacture of organic chemials only, or both organic chemicals and plastics and synthetic fibers, that include wastewater from any of the following generic processes (referred to in the BPT Development document as "Type I" processes) but not from the oxidation process:

Peroxidation
Acid Cleavage
Condensation
Isomerization
Esterification
Hydroacetylation
Hydration
Alkoxylation
Hydrolysis
Carbonylation
Hydrogenation
Neutralization

Subcategory 4 - Other Discharges

All OCPS discharges not included in Subcategories 1-3.

SECTION V.

SELECTION OF POLLUTANT PARAMETERS

WASTEWATER PARAMETERS

Specific conventional and nonconventional wastewater parameters were determined to be significant in the Organic Chemicals and Plastics and Synthetic Materials Industries and were selected for evaluation based on: (1) an industry characterization, (2) data collected from sampling efforts, (3) historical data collected from the literature, and (4) data provided by industry questionnaires (308 Portfolio).

Conventional pollutant parameters chosen for evaluation include 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), pH, and oil and grease (O&G). Nonconventional pollutant parameters selected are chemical oxygen demand (COD) and total organic carbon (TOC).

CONVENTIONAL POLLUTANT PARAMETERS

5-day Biochemical Oxygen Demand (BOD_5)

The 5-day Biochemical Oxygen Demand (BOD_5) test traditionally has been used to determine the strength of domestic and industrial wastewaters. It is a measure of the oxygen required by biological organisms to assimilate the biodegradable portion of a waste under aerobic conditions. [5-1] Substances that may contribute to the BOD include carbonaceous materials usable as a food source by aerobic organisms; oxidizable nitrogen derived from organic nitrogen compounds, ammonia and nitrites that are oxidized by specific bacteria; and chemically oxidizable materials such as ferrous compounds, sulfides, sulfite, and similar reduced-state inorganics that will react with dissolved oxygen or that are metabolized by bacteria.

The BOD of a wastewater is a measure of the dissolved oxygen depletion that might be caused by the discharge of that wastewater to a body of water. This depletion reduces the oxygen available to fish, plant life, and other aquatic species. Total exhaustion of the dissolved oxygen in water results in anaerobic conditions, and the subsequent dominance of anaerobic species that can produce undesirable gases such as hydrogen sulfide and methanol. The reduction of dissolved oxygen can be detrimental to fish populations, fish growth rates, and organisms used as fish food. A total lack of oxygen can result in the death of all aerobic aquatic inhabitants in the affected area.

The BOD_5 (5-day BOD) test is widely used to estimate the oxygen demand of domestic and industrial wastes and to evaluate the performance of waste treatment facilities. The test is widely used for measuring potential pollution since no other test methods have been developed that are as suitable or as widely accepted for evaluating the deoxygenation effect of a waste on a receiving water body.

The BOD test measures the weight of dissolved oxygen utilized by microorganisms as they oxidize or transform the gross mixture of chemical

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compounds in the wastewater. The degree of biochemical reaction involved in the oxidation of carbon compounds is related to the period of incubation. When municipal sewage is tested, BOD_5 normally measures only 60 to 80 percent of the total carbonaceous biological oxygen demand of the sample. When testing OCPS wastewaters, however, the fraction of total carbonaceous oxygen demand measured can range from less than 10 percent to more than 80 percent. The actual percentage for a given waste stream will depend on the degradation characteristics of the organic components present, the degree to which the seed is acclimated to these components, and the degree to which toxic or inhibitory components are present in the waste.

Total Suspended Solids TSS

Suspended solids can include both organic and inorganic materials. The inorganic materials include sand, silt and clay and may include insoluble toxic metal compounds. The organic fraction includes such materials as grease, oils, animal and vegetable waste products, fibers, microorganisms and many other dispersed insoluble organic compounds. [5-2] These solids may settle rapidly and form bottom deposits that are often a mixture of both organic and inorganic solids.

Solids may be suspended in water for a time and then settle to the bottom of a stream or lake. They may be inert, slowly biodegradable materials, or they may be rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration, and impair the photosynthetic activity of aquatic plants. After settling to the stream or lake bed, the solids can form sludge banks, which, if largely organic, create localized anaerobic and undesirable benthic conditions. Aside from any toxic effect attributable to substances leached out by water, suspended solids may kill fish and shellfish by causing abrasive injuries, clogging gills and respiratory passages, screening light, and by promoting and maintaining noxious conditions through oxygen depletion.

Suspended solids may also reduce the recreational value of a waterway and can cause problems in water used for domestic purposes. Suspended solids in intake water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on exposed equipment, especially at elevated temperatures.

pH

The term pH describes the hydrogen ion-hydroxyl ion equilibria in water. Technically, pH is a measure of the hydrogen ion concentration or activity present in a given solution. A pH number is the negative logarithm of the hydrogen ion concentration. A pH of 7.0 indicates neutrality or a balance between free hydrogen and free hydroxyl ions. A pH above 7.0 indicates that a solution is alkaline; a pH below 7.0 indicates that a solution is acidic.

The pH of discharge water is of concern because of its potential impact on the receiving body of water. Wastewater effluent, if not neutralized before release, may alter the pH of the receiving water. The critical range suitable for the existence of most biological life is quite narrow, lying between pH 6 and pH 9.

Extremes of pH or rapid pH changes can harm or kill aquatic life. Even moderate changes from acceptable pH limits can harm some species. A change in the pH of water may increase or decrease the relative toxicity of many materials to aquatic life. A drop of even 1.5 units, for example, can increase the toxicity of metalocyanide complexes a thousandfold. The bactericidal effect of chlorine in most cases lessens as the pH increases.

Waters with a pH below 6.0 corrode waterworks structures, distribution lines, and household plumbing fixtures. This corrosion can add to drinking water such constituents as iron, copper, zinc, cadmium, and lead. Low pH waters not only tend to dissolve metals from structures and fixtures, but also tend to redissolve or leach metals from sludges and bottom sediments.

Normally, biological treatment systems are maintained at a pH between 6 and 9; however, once acclimated to a narrow pH range, sudden deviations (even in the 6 to 9 range) can cause upsets in the treatment system with a resultant decrease in treatment efficiency.

Oil and Grease (O & G)

Oil and grease analyses do not actually measure the quantity of a specific substance, but measure groups of substances whose common characteristic is their solubility in freon. Substances measured may include hydrocarbons, fatty acids, soaps, fats, oils, wax and other materials extracted by the solvent from an acidified sample and not volatilized by the conditions of the test. As a result, the term oil and grease is more properly defined by the conditions of the analysis rather than by a specific compound or group of compounds. Additionally, the material identified in the O&G determination is not necessarily free floating. It may be actually in solution but still extractable from water by the solvent.[5-3]

Oils and greases of hydrocarbon derivative, even in small quantities, cause troublesome taste and odor problems. Scum lines from these agents are produced on water treatment basin walls and other containers. Fish and water fowl are adversely affected by oils in their habitat. Oil emulsions may cause the suffocation of fish by adhering to their gills and may taint the flesh of fish when microorganisms exposed to waste oil are eaten. Deposition of oil in the bottom sediments of natural waters can serve to inhibit normal benthic growth. Oil and grease can also exhibit an oxygen demand.

Levels of oil and grease that are toxic to aquatic organism vary greatly depending on the oil and grease components and the susceptibility of the species exposed to them. Crude oil in concentrations as low as 0.3 mg/l can be extremely toxic to freshwater fish. Oil slicks prevent the full aesthetic enjoyment of water. The presence of oil in water can also increase the toxicity of other substances being discharged into the receiving bodies of water. Municipalities frequently limit the quantity of oil and grease that can be discharged to their wastewater treatment systems by industry, since large quantities of O&G can cause difficulties in biological treatment systems.

There are several approved modifications of the analysis for oil and grease. Each is designed to increase the accuracy or enhance the selectivity of the analysis. Depending on the procedure and detection method employed, the accuracy of the test can vary from 88 percent for the Soxhlet Extraction Method to 99 percent for the Partition-Infrared Method.

NONCONVENTIONAL POLLUTANT PARAMETERS

Chemical Oxygen Demand (COD)

COD is a chemical oxidation test devised as an alternate method of estimating the oxygen demand of a wastewater. Since the method relies on the oxidation-reduction system of a chemical reaction rather than a biological reaction, it is more precise, accurate, and rapid than the BOD_5 test. The COD test is sometimes used to estimate the total oxygen (ultimate rather than 5-day BOD) required to oxidize the compounds in a wastewater. In the COD test strong chemical oxidizing agents under acid conditions, with the assistance of certain inorganic catalysts, can oxidize most organic compounds, including many that are not biodegradable. [5-4]

The COD test measures organic components that may exert a biological oxygen demand and may affect public health. It is a useful analytical tool for pollution control activities. Most pollutants measured by the BOD_5 test will be measured by the COD test. In addition, pollutants resistant to biochemical oxidation will also be measured as COD.

Compounds resistant to biochemical oxidation are of great concern because of their slow, continuous oxygen demand on the receiving water and also, in some cases, because of their potential health effects on aquatic life and humans. Many of these compounds result from industrial discharges and some of the compounds have been found to have carcinogenic, mutagenic, and similar adverse effects. Concern about these compounds has increased as a result of demonstrations that their long life in receiving water (the result of a low biochemical oxidation rate) allows them to contaminate downstream water intakes. The commonly used systems of water purification are not effective in removing these types of materials and disinfection with chlorine may convert them into even more objectionable materials.

It should be noted that the COD test may not measure the oxygen demand of certain aromatic species such as benzene, toluene and pyridine.

Total Organic Carbon (TOC)

TOC measures all oxidizable organic material in a waste stream, including the organic chemicals not oxidized (and therefore not detected) in BOD and COD tests. TOC analysis is a rapid test for estimating the total organic carbon in a wastestream.

When testing for TOC, the organic carbon in a sample is converted to carbon dioxide (CO_2) by catalytic combusion or by wet chemical oxidation. The CO_2 formed can be measured directly by an infrared detector or it can be converted to methane (CH_4) and measured by a flame ionization detector. The amount of CO_2 or CH_4 is directly proportional to the concentration of carbonaceous material in the sample. TOC tests are usually performed on commercially available automatic TOC analyzers. Inorganic carbons, including carbonates and bicarbonates, interfere with these analyses and must be removed during sample preparation.[5-5]

SECTION VI.

WATER USE AND WASTEWATER CHARACTERIZATION

WATER USE AND SOURCES OF WASTEWATER

Water use and wastewater generation occur at a number of points in OCPS manufacturing processes and ancillary operations, including: (1) direct and indirect process contact, (2) contact and noncontact cooling water, (3) utilities, maintenance and housekeeping, and (4) air pollution control systems such as Venturi scrubbers.

An example of direct process contact water is the use of aqueous reaction media. The use of water as a media for certain chemical processes becomes a major high strength wastewater source after the primary reaction has been completed and the final product has been separated from the water media, leaving unwanted by-products formed during secondary reactions in solution.

Indirect process contact waters, such as those discharged from vacuum jets and steam ejectors, involve the recovery of solvents and volatile organics from the chemical reaction kettle. In using vacuum jets, a stream of water is used to create a vacuum, but also draws off volatilized solvents and organics from the reaction kettle into solution. Later, recoverable solvents are separated and reused while unwanted volatile organics remain in solution in the vacuum water which is discharged as wastewater. Steam ejector systems are similar to vacuum jets with steam being substituted for water. The steam is then drawn off and condensed to form a source of wastewater.

The major volume of water use in the OCPS industry is cooling water. Cooling water may be contaminated, such as contact cooling water from barometric condensers, or uncontaminated noncontact cooling water. Frequently, large volumes of cooling water may be used on a once-through basis and discharged with process wastewater. Many of the effluent values reported by plants in the data bases were based on flow volumes which included their cooling water. An adjustment of the reported volumes of the effluents was therefore required to arrive at performance of treatment systems and other effluent characteristics. This adjustment was made by eliminating the uncontaminated cooling water volume from the total volume, to arrive at the contaminated wastewater flow. Concentrations also were adjusted using the simplifying judgment that the uncontaminated cooling water did not contribute to the pollutant level. However, it should be noted that in some cases cooling water can contribute relatively high TSS loading, especially to typically low strength plastics and synthetic materials wastewaters.

Tables 6-1 and 6-2 present treated effluent wastewater and raw waste flows reported by direct discharge plants and zero or alternative discharge disposal plants, respectively, for each of the four proposed subcategories. The adjusted flows presented were calculated from all raw and treated wastewater streams reported with the number of observations corresponding to the total number of reported waste stream flows. It

TABLE 6-1

EFFLUENT FLOWS FOR PROPOSED SUBCATEGORIES DIRECT DISCHARGERS ONLY

	PLASTICS ONLY	NOT PLASTICS TYPE I w/ OXIDATION	NOT PLASTICS TYPE I w/o OXIDATION	NOT PLASTICS NOT TYPE I
	EFF FLOW MGD	EFF FLOW MGD	EFF FLOW MGD	EFF FLOW MGD
MAXIMUM	10.700	29.000	32.100	40.000
MEAN	1.357	2.771	2.464	3.346
MINIMUM	0.034	0.008	0.020	0.007
MEDIAN	0.612	1.010	0.852	0.950
NUMBER OF OBSERVATIONS	74	63	34	35

TABLE 6-2

INFLUENT AND EFFLUENT FLOWS FOR PROPOSED SUBCATEGORIES ZERO DISCHARGE/ALTERNATIVE DISPOSAL ONLY

	PLASTICS ONLY		NOT PLASTICS TYPE I w/ OXIDATION		NOT PLASTICS TYPE I w/o OXIDATION		NOT PLASTICS NOT TYPE I	
	INF(1) FLOW MGD	EFF FLOW MGD	INF (1) FLOW MGD	EFF FLOW MGD	INF (1) FLOW MGD	EFF FLOW MGD	INF(1) FLOW MGD	EFF FLOW MGD
MAXIMUM	10.700	.	5.329	.	4.030	.	2.600	.
MEAN	0.530	.	1.009	.	0.475	.	0.500	.
MINIMUM	0.000	.	0.000	.	0.000	.	0.001	.
MEDIAN	0.012	.	0.271	.	0.152	.	0.118	.
NUMBER OF OBSERVATIONS	29		20		14		14	

(1) Since effluent flow for these plants is by definition zero, influent flows are presented

should be noted that the number of streams does not correspond to the number of plants due to the existence of multi-stream plants.

WASTEWATER CHARACTERIZATION

A number of different pollutant parameters are used to characterize wastewater discharged by OCPS facilities. These include:

1. Biochemical Oxygen Demand (BOD)
2. Suspended Solids (TSS)
3. pH
4. Chemical Oxygen Demand (COD)
5. Total Organic Carbon (TOC)
6. Oil and Grease (O&G)

BOD is one of the most important gauges of the pollution potential of a wastewater and varies with the amount of biodegradable matter which can be assimilated by biological organisms under aerobic conditions. Large, complex facilities tend to discharge a higher BOD mass loading, although concentrations are not necessarily different from smaller or less complex plants. The nature of specific chemicals discharged into wastewater affects the BOD due to the differences in susceptability of different molecular structures to microbiological degradation. Compounds with lower susceptability to decomposition by microorganisms tend to exhibit lower BOD values even though the total organic loading may be much higher than compounds exhibiting substantially higher BOD values.

Raw wastewater TSS is a function of the products manufactured and their processes, as well as the manner in which fine solids that may be removed by a processing step are handled in the operations. It can also be a function of a number of other external factors including stormwater runoff, runoff from raw material storage areas, and landfill leachates which may be diverted to the wastewater treatment system. Solids are frequently washed into the plant sewer and removed at the wastewater treatment plant. The solids may be organic, inorganic or a mixture of both. Settleable portions of the suspended solids are usually removed in a primary clarifier. Finer materials are carried through the system, and in the case of an activated sludge system, become enmeshed with the biomass where they are then removed with the sludge during secondary clarification. Many of the manufacturing plants show an increase in TSS after wastewater leaves the treatment plant. This characteristic is usually associated with biological systems and indicates an inefficiency of secondary clarification in the removal of secondary solids. However, in plastics and synthetic materials wastewaters, formation of biological solids within the treatment plant may cause this solids increase due to the low strength nature of the waste.

Raw wastewater pH can be a function of the nature of the processes contributing to the waste stream. This parameter can vary widely from plant to plant and can also show extreme variations in a single plant's raw wastewater, depending on such factors as waste concentration and the portion of the process cycle discharging at the time of measurement. Fluctuations in pH are readily reduced by equalization followed by a neutralization system, if necessary. pH control is important regardless of the disposition of the wastewater stream (i.e, indirect discharge to a POTW or direct discharge) to maintain favorable conditions for biological treatment organisms.

COD is a measure of oxidizable material in a wastewater as determined by subjecting the waste to a powerful chemical oxidizing agent (such as dichromate) under standardized conditions. Therefore, the COD test shows the presence of organic materials that are not susceptable to attack by biological microorganisms. As a result of this difference, COD values are almost invariably higher than BOD values for the same sample. The COD test cannot be substituted directly for the BOD test because the COD/ BOD ratio is a factor which is extremely variable and is very dependent on the specific chemical constituents in the wastewater. However, a COD/ BOD ratio for the wastewater from a single manufacturing facility can be established. This ratio is applicable only to the wastewater from which it was derived and cannot be utilized to estimate the BOD of another plant's wastewater. It is often established by plant personnel to monitor process and treatment plant performance with a minimum of analytical delay. As production rate and product mix changes, however, the COD/BOD ratio must be revalidated for the new conditions. Even if there are no changes in production, the ratio should be reconfirmed periodically.

TOC measurement is another means of determining the pollution potential of wastewater. This measurement shows the presence of organic compounds not necessarily measured by either BOD or COD tests. TOC can also be related to the BOD and COD by ratio, but it too is only applicable to the specific wastewater for which the ratio is derived. TOC determination is also useful for day-to-day control of treatment operations.

Oil and grease determinations do not measure the quantity of a specific substance but measure substances whose common characteristic is their solubility in freon. Treatment of oil and grease involves dissolved air flotation and skimming practices. If these procedures are implemented and efficiently used and maintained, oil and grease values should be substantially lowered. Therefore, plants discharging high oil and grease values may reflect limited use of available treatment technologies and limited source controls for oil and grease abatement.

Tables 6-3 through 6-10 present raw wastewater characteristics for each of the four proposed subcategories. Minimum, maximum, mean and median concentration values as well as mass loading in pounds per day for all pollutant parameters of interest (BOD, TSS, COD, TOC and O&G) are presented for direct discharge plants and zero or alternative discharge/ disposal facilities.

Each set of observations shown in Tables 6-1 thru 6-10 should be considered a separate data subset, independent of other data subsets presented. Calculations which involve more than one data subset (i.e., determining BOd/COD ratios) may not be meaningful, since data subsets do not reflect the same group of plants. Similarly, multiplying the median concentration for some parameter by the mean flow will not correspond to the median pounds for that parameter.

TABLE 6-3
RAW WASTEWATER CHARACTERISTICS - PLASTICS ONLY SUBCATEGORY
DIRECT DISCHARGERS ONLY

	INF BOD MG/L	INF BOD LB/DAY	INF TSS MG/L	INF TSS LB/DAY	INF COD MG/L	INF COD LB/DAY	INF TOC MG/L	INF TOC LB/DAY	INF O&G MG/L	INF O&G LB/DAY
MAXIMUM	3520.0	25262.0	2898.0	16082.3	4338.0	51392.6	2751.0	5560.8	242.0	2355.7
MEAN	506.2	3693.4	394.4	2263.0	1101.6	8315.9	705.4	1720.7	82.3	710.8
MINIMUM	2.0	13.0	5.0	1.5	27.0	60.5	9.0	13.0	23.0	72.9
MEDIAN	349.0	1985.8	80.0	803.3	857.0	4889.5	362.0	949.9	32.0	207.3
NUMBER OF OBSERVATIONS	49	49	42	42	45	45	8	8	4	4

Note: Each set of observations represents a separate data subset. Calculations which combine subsets may not be meaningful. (See last paragraph page 109.)

TABLE 6-4

RAW WASTEWATER CHARACTERISTICS - PLASTICS ONLY SUBCATEGORY
ZERO DISCHARGE/ALTERNATIVE DISPOSAL ONLY

	INF BOD MG/L	INF BOD LB/DAY	INF TSS MG/L	INF TSS LB/DAY	INF COD MG/L	INF COD LB/DAY	INF TOC MG/L	INF TOC LB/DAY	INF O&G MG/L	INF O&G LB/DAY
MAXIMUM	12542.0	4174.0	1055.0	351.1	18549.0	6173.1	1938.0	201.6	.	.
MEAN	4110.7	1232.3	317.7	105.6	5303.4	2068.4	923.0	82.3	.	.
MINIMUM	388.0	111.7	0.3	1.7	48.0	6.0	31.0	16.8	.	.
MEDIAN	1378.0	327.6	237.0	29.1	1422.0	1107.4	800.0	26.6	.	.
NUMBER OF OBSERVATIONS	6	6	5	5	5	5	3	3	0	0

Note: Each set of observations represents a separate data subset. Calculations which combine subsets may not be meaningful. (See last paragraph page 109.)

TABLE 6-5

RAW WASTEWATER CHARACTERISTICS -
TYPE I WITH OXIDATION SUBCATEGORY

DIRECT DISCHARGERS ONLY

	INF BOD MG/L	INF BOD LB/DAY	INF TSS MG/L	INF TSS LB/DAY	INF COD MG/L	INF COD LB/DAY	INF TOC MG/L	INF TOC LB/DAY	INF O&G MG/L	INF O&G LB/DAY
MAXIMUM	5961.0	249714.3	4110.0	34195.2	21178.0	202706.2	3202.0	115196.9	17.4	351.8
MEAN	1702.1	25975.2	441.6	3949.8	4414.6	40369.9	836.4	24792.7	11.4	180.1
MINIMUM	43.0	939.7	9.0	19.0	53.0	1409.6	20.0	49.9	0.8	42.1
MEDIAN	1036.5	13289.5	72.0	672.9	3302.5	19714.5	513.0	13334.0	16.0	146.4
NUMBER OF OBSERVATIONS	42	42	21	21	34	34	21	21	3	3

Note: Each set of observations represents a separate data subset. Calculations which combine subsets may not be meaningful. (See last paragraph page 109.)

TABLE 6-6

RAW WASTEWATER CHARACTERISTICS -
NOT PLASTICS TYPE I WITH OXIDATION SUBCATEGORY
ZERO DISCHARGE/ALTERNATIVE DISPOSAL ONLY

	INF BOD MG/L	INF BOD LB/DAY	INF TSS MG/L	INF TSS LB/DAY	INF COD MG/L	INF COD LB/DAY	INF TOC MG/L	INF TOC LB/DAY	INF O&G MG/L	INF O&G LB/DAY
MAXIMUM	52554.0	374100.5	459.0	7994.6	67095.0	592650.2	11006.0	201826.6	539.0	5829.8
MEAN	14532.4	71520.6	207.7	4150.1	26441.4	147345.6	5746.0	85417.3	539.0	5829.8
MINIMUM	450.0	2566.9	61.0	659.0	960.0	7474.0	282.0	21888.1	539.0	5829.8
MEDIAN	6022.0	20550.7	103.0	3796.0	23744.0	74623.0	5849.5	56977.2	539.0	5829.8
NUMBER OF OBSERVATIONS	7	7	3	3	9	9	4	4	1	1

Note: Each set of observations represents a separate data subset. Calculations which combine subsets may not be meaningful. (See last paragraph page 109.)

TABLE 6-7

RAW WASTEWATER CHARACTERISTICS - NOT PLASTICS TYPE I WITHOUT OXIDATION SUBCATEGORY

DIRECT DISCHARGERS ONLY

	INF BOD MG/L	INF BOD LB/DAY	INF TSS MG/L	INF TSS LB/DAY	INF COD MG/L	INF COD LB/DAY	INF TOC MG/L	INF TOC LB/DAY	INF O&G MG/L	INF O&G LB/DAY
MAXIMUM	2725.0	30913.8	2666.0	16925.5	32476.0	71448.8	5226.0	31089.9	570.0	591.2
MEAN	783.6	9384.2	479.7	2624.7	4782.5	11982.2	940.8	6343.8	335.0	365.4
MINIMUM	9.0	6.0	1.0	0.7	23.0	18.6	66.0	342.1	17.0	94.8
MEDIAN	467.0	5624.3	170.0	594.0	1022.0	6139.0	272.0	2109.1	418.0	410.2
NUMBER OF OBSERVATIONS	21	21	13	13	15	15	11	11	3	3

Note: Each set of observations represents a separate data subset. Calculations which combine subsets may not be meaningful. (See last paragraph page 109.)

TABLE 6-8

RAW WASTEWATER CHARACTERISTICS -
NOT PLASTICS TYPE I WITHOUT OXIDATION SUBCATEGORY

ZERO DISCHARGE/ALTERNATIVE DISPOSAL ONLY

	INF BOD MG/L	INF BOD LB/DAY	INF TSS MG/L	INF TSS LB/DAY	INF COD MG/L	INF COD LB/DAY	INF TOC MG/L	INF TOC LB/DAY	INF O&G MG/L	INF O&G LB/DAY
MAXIMUM	3044.0	7597.8	267.0	755.3	11966.0	29867.1	364.0	663.2	.	.
MEAN	1019.0	2410.4	106.3	397.2	3600.5	8726.6	223.0	523.1	.	.
MINIMUM	42.0	29.7	32.0	82.4	14.0	9.9	130.0	411.0	.	.
MEDIAN	495.0	1007.1	63.0	375.6	1211.0	2514.6	175.0	495.0	.	.
NUMBER OF OBSERVATIONS	4	4	4	4	4	4	3	3	0	0

Note: Each set of observations represents a separate data subset. Calculations which combine subsets may not be meaningful. (See last paragraph page 109.)

TABLE 6-9

RAW WASTEWATER CHARACTERISTICS - NOT PLASTICS NOT TYPE I SUBCATEGORY

DIRECT DISCHARGERS ONLY

	INF BOD MG/L	INF BOD LB/DAY	INF TSS MG/L	INF TSS LB/DAY	INF COD MG/L	INF COD LB/DAY	INF TOC MG/L	INF TOC LB/DAY	INF O&G MG/L	INF O&G LB/DAY
MAXIMUM	1743.0	59904.0	1266.0	36940.8	5488.0	66663.8	1455.0	64563.2	420.0	6988.8
MEAN	421.7	9835.4	456.5	7383.6	1623.5	15229.4	376.6	10759.9	235.0	3606.9
MINIMUM	95.0	435.4	17.0	14.9	218.0	223.7	35.0	72.0	50.0	225.1
MEDIAN	318.0	3083.9	138.0	1723.4	590.0	5899.1	184.5	1992.7	235.0	3606.9
NUMBER OF OBSERVATIONS	11	11	13	12	13	13	8	8	2	2

Note: Each set of observations represents a separate data subset. Calculations which combine subsets may not be meaningful. (See last paragraph page 109.)

TABLE 6-10

RAW WASTEWATER CHARACTERISTICS - NOT PLASTICS NOT TYPE I SUBCATEGORY

ZERO DISCHARGE/ALTERNATIVE DISPOSAL

	INF BOD MG/L	INF BOD LB/DAY	INF TSS MG/L	INF TSS LB/DAY	INF COD MG/L	INF COD LB/DAY	INF TOC MG/L	INF TOC LB/DAY	INF O&G MG/L	INF O&G LB/DAY
MAXIMUM	1439.0	5646.0	33178.0	183843.3	27872.0	154442.1	9592.0	1197.1	286.0	6186.8
MEAN	631.0	1997.5	10230.3	46798.1	9980.8	37921.0	4876.5	668.2	286.0	6186.8
MINIMUM	193.0	167.0	81.0	70.1	546.0	472.4	161.0	139.3	286.0	6186.8
MEDIAN	261.0	179.6	3831.0	1639.5	2956.0	2607.0	4876.5	668.2	286.0	6186.8
NUMBER OF OBSERVATIONS	3	3	4	4	5	5	2	2	1	1

Note: Each set of observations represents a separate data subset. Calculations which combine subsets may not be meaningful. (See last paragraph page 109.)

SECTION VII.

CONTROL AND TREATMENT TECHNOLOGIES

GENERAL

This chapter addresses control and treatment technologies currently used or available to the OCPS industries for BPT. The treatment methodologies presented in this section are divided into in-plant technologies, including source control and in-plant treatment, and end-of-pipe (EOP) technologies.

Wastewaters from the OCPS industries are disposed of by one of three methods: (1) direct discharge, (2) indirect discharge, and (3) zero or alternative discharge. Direct discharge refers to the release of treated or untreated wastewater to a receiving stream. Indirect dischargers transport wastewater to a publicly owned treatment works (POTW). Zero or alternate discharge refers to situations in which generated wastewater is either disposed of on plant property or transferred to an alternate location where it is disposed of on-site or discharged after treatment.

Table 7-1 lists the zero or alternate discharge practices and the principal direct discharge end-of-pipe treatment technologies reflected by the Summary Data Base. The principal disposal/treatment practices are grouped by the number of waste streams and the number of plants for the four potential subcategories discussed in Section IV.

A total of 71 plants are single stream zero or alternate dischargers, and 23 plants are multiple stream zero or alternate dischargers. The largest group of plants in the data base are the 157 single pipe direct dischargers. Five other plants have multiple direct discharge streams. An additional 33 plants have both zero or alternate and direct discharge streams. The disposal method used at 2 plants could not be determined. Although the Summary Data Base was only developed for direct and zero or alternative discharge, six plants are currently indirect dischargers because they have diverted their effluents to a POTW. Data collected at these plants while they were direct dischargers has been retained in the Summary Data Base.

IN-PLANT SOURCE CONTROLS

In-plant source control refers to process or operating techniques used to either reduce the quantity or improve the quality of a waste stream within a plant. Some in-plant control methodologies are capable of completely eliminating a waste stream, while others recover valuable by-products of the manufacturing process.

In-plant controls provide several advantages. Beyond the potential for recovery of saleable material, in-plant control may reduce EOP treatment plant costs, which often offset the in-plant treatment costs. In-plant control can also remove pollutants inhibitory or not amenable to EOP treatment schemes.

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TABLE 7-1

PRINCIPLE TREATMENT/DISPOSAL PRACTICE

DIS-POSAL CODE	PRINCIPAL DESIGNATION	PLASTICS ONLY		NOT PLASTICS TYPE I & C*		NOT PLASTICS TYPE I NOT C**		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
		NO. OF PLANTS	NO. OF WASTE STREAMS	NO. OF PLANTS	NO. OF WASTE STREAMS	NO. OF PLANTS	NO. OF WASTE STREAMS	NO. OF PLANTS	NO. OF WASTE STREAMS	NO. OF PLANTS	NO. OF WASTE STREAMS
	ZERO DISCHARGE										
BRN	INCINERATION	3	10	2	11	1	1	1	2	7	24
CON	CONTRACT HAUL	11	16	0	0	1	3	3	3	15	22
DPW	DEEP WELL	2	3	2	12	0	6	3	6	7	27
DRY	DRY PROCESS (REPORTED)	12	15	1	11	4	4	3	5	20	35
EVP	EVAPORATION	2	2	0	0	0	0	0	0	2	2
IMP	IMPOUNDMENT	3	7	4	5	3	4	2	2	12	18
LAP	LAND APPLICATION	3	3	0	0	0	0	0	0	3	3
OFS	OFF-SITE TREATMENT	1	1	2	2	0	0	1	3	4	6
RTE	RECYCLE	9	10	11	11	2	2	2	2	24	25
	TOTAL ZERO	46	67	22	52	11	20	15	23	94	162
	DIRECT DISCHARGE										
ALA	AERATED LAGOON	8	8	9	9	4	4	5	6	26	27
ANL	ANAEROBIC	0	0	2	2	0	0	0	0	2	2
APL	AEROBIC LAGOON	2	3	0	0	1	1	1	1	4	5
ASL	ACTIVATED SLUDGE	40	40	40	42	14	15	10	10	104	107
OXY	UNOX	0	0	0	0	2	2	1	1	3	3
RBC	ROTATING BIOLOGICAL CONTACTOR	4	4	0	0	0	0	0	0	4	4
TRF	TRICKLING FILTER	1	1	0	0	1	1	1	1	3	3
	TOTAL BIOLOGICAL	55	56	51	53	22	23	18	19	146	151
ACR	ACTIVATED CARBON	0	0	1	1	2	3	3	3	6	7
CLR	CLARIFICATION	5	7	0	0	1	1	2	2	8	10
DAF	DISSOLVED AIR FLOATATION	0	0	0	0	0	0	1	1	1	1
MMF	MULTI-MEDIA FILTRATION	0	0	1	1	0	0	0	0	1	1
NEU	NEUTRALIZATION	0	1	0	0	3	3	6	6	9	10
OLS	OIL WATER SEPARATION	2	5	1	2	0	0	1	2	4	9
PCF	PPT.,COAGULATION,FILTRATION	1	1	0	0	2	2	0	0	3	3
SSK	SKIMMING	3	3	0	0	1	1	0	0	4	4
STR	STEAM STRIPPING	0	0	1	1	0	0	2	2	3	3
	TOTAL NON-BIOLOGICAL	11	17	4	5	9	10	15	16	39	48
NOT	NO TREATMENT	4	4	3	6	2	2	1	1	10	13
UNK	UNKNOWN	2	2	0	1	0	0	0	0	2	3
	GRAND TOTAL	118	146	80	117	44	55	49	59	291	377

* Type I w/Oxidation

** Type I w/o/Oxidation

Many of the newer chemical manufacturing plants are being designed with a reduction in water use and consequent minimization of contamination as part of the overall planning and plant design criteria. In addition, improvements have been made in existing plants to control pollution from their manufacturing processes and other activities, prior to discharge. In-plant source controls that have been effective in reducing pollution loads in the OCPS industries are described in the following paragraphs.

Process Modification

Older plants were sometimes designed without regard for raw material or water conservation. As costs have increased and local environmental regulations have become more stringent, some plants have modified their manufacturing processes. For example, plants which once used batch processes have gone to continuous operation. By doing so, wastewaters containing spent solvents or caustic which are generated by between batch cleanup are eliminated. As a consequence, production yields increase and overall wastewater generation is reduced.

Instrumentation

An important source of pollutant loading in the OCPS industries is occasional process upset resulting in discharge of products, raw materials or by-product. For example, reaction kettles occasionally become over pressurized, resulting in a burst rupture-disc and subsequent discharge.

The in-plant control best suited to eliminate these occurrences is the installation of more sophisticated instrumentation. Alarms, pH and flow sensors and similar devices are capable of early detection of process upsets. Use of this type of instrumentation, coupled with added operator training, can measurably reduce pollutant loading.

Solvent Recovery

The recovery of waste solvents has become a common practice among plants using solvents in their manufacturing processes. However, several plants have instituted further measures to reduce the amount of waste solvents discharged. Such measures include incineration of solvents that cannot be recovered economically, incineration of bottoms from solvent recovery units, and design and construction of better solvent recovery columns to strip solvents beyond the economical recovery point. The economical recovery point has been reached when the cost of recovering additional solvent (less the value of the recovered solvent) is greater than the cost of treating or disposing of the remaining waste solvent.

Water Reuse, Recovery, and Recycle

The use of barometric condensers can result in significant water contamination, depending upon the nature of the materials entering the discharge water streams. As an alternative, several plants use surface condensers to reduce hydraulic or organic loads.

Water-sealed vacuum pumps often create water pollution problems. Several plants use a recirculation system as a means of greatly reducing the amount of water being discharged.

Reduction of once-through cooling water by recycling through cooling towers is a common industrial practice which results in a decreased total discharge volume. Stormwater runoff from manufacturing areas can contain significant quantities of pollutants. Separation of stormwater from process wastewater has been practiced throughout the industry and often facilitates the isolation and treatment of contaminated runoff.

Process modifications allowing for enhanced wastewater recycle have also been applied within the OCPS industry. Twenty-four facilities in the 291 plant Summary Data Base indicate that, through wastewater recycle, they achieve zero discharge.

IN-PLANT TREATMENT

Besides implementing source controls to reduce or eliminate the waste loads generated within a manufacturing process, another alternative is available. In-plant treatment is directed toward removing certain pollutants before they are combined with the plant's overall wastewaters and consequently diluted. In a general sense, in-plant treatment processes are designed to treat specific waste streams. Although in-plant technologies can remove a variety of pollutants, they are usually designed to treat toxic or priority pollutants.

Generally speaking, in-plant treatment is employed to avoid undesirable impacts on a plant's end-of-pipe (EOP) treatment. Indirect dischargers may utilize in-plant treatment to remove components which could detrimentally affect the POTW, or materials which could pass through a POTW without receiving adequate treatment. In-plant treatment is also used to take advantage of the more efficient treatment of low volume, concentrated and homogenous waste streams generated by specific unit operations.

The basis for any decision to employ in-plant treatment is governed by the presence of:

- Pollutants toxic to the biota of an EOP biological treatment system.
- Biologically refractive pollutants.
- Highly concentrated pollutants.
- Pollutants that may offer an economic recovery potential (solvent recovery).
- Pollutants that are hazardous if combined with other chemicals downstream.
- Pollutants generated in small volumes in remote areas, precluding conveyance to centralized treatment.

- Corrosive pollutants that are difficult to transport.

- Pollutants that would contaminate EOP waste sludge, limiting disposal options.

Many demonstrated technologies are available for the removal of specific pollutants found in the wastewaters from organics and plastics manufacture. The selection of a specified in-plant treatment scheme depends both on the nature of the pollutant to be removed and on the engineering and cost comparisons of the options available.

The following paragraphs provide brief summaries of technologies either in use as in-plant treatment technology, or available to the OCPS industry. In that in-plant treatment is primarily used to remove toxic materials (i.e., metals, cyanide, solvents, etc.), the reader is referred to the BAT Development Document for further details on these treatment processes.

Activated Carbon Adsorption

Adsorption on granular activated carbon (GAC) is an effective, and moreover, a commercially established means of removing dissolved organic species from aqueous waste streams. Contaminants are removed from solution by a three-step process involving (1) transport to the exterior of the carbon, (2) diffusion within the pores of the activated carbon, and (3) adsorption on the interior surfaces bounding the pore and capillary spaces of the activated carbon. Eventually the surface of the carbon is saturated. When this occurs, replacement of the adsorber system with fresh (i.e., virgin or reactivated) carbon is required.

Both powdered activated carbon (PAC) and GAC are capable of efficiently removing many pollutants, including toxic and refractory organics. Powdered carbon is most frequently added to biological treatment processes and is not recovered.

Table 7-2 was taken from a recently published study [7-1] of carbon adsorption systems which have been in use in the chemical industry. The table lists more than 100 examples of full scale activated carbon adsorption systems.

Metals Removal

Heavy metals are of importance since their presence even at very low levels can inhibit biological activity and thereby lower the efficiency of the biological treatment system.

Technologies are well established for a number of metals removal methods. Hydroxide and sulfide precipitations, for example, are the most common methods of metal ion removal used. Many metals ions form insoluble hydroxides and sulfides at a high pH when treated with either caustic soda, lime, or soluble sulfides. The precipitates may be removed from the waste stream by such methods as settling or filtration. Other technologies applicable to metals removal are ion exchange and

TABLE 7-2

COMPANIES REPORTED TO HAVE EXPERIENCE WITH FULL-SCALE GRANULAR ACTIVATED CARBON SYSTEMS [7-5]

Company	Location	Principal Product
Alkcolac	Sedalia, MO	Surface active agents
Allied Chemical	Fairfield, AL	Creosote oils, tars, pitches
	South Point, OH	Formaldehyde
	Frankford, PA	Organic chemicals
	Buffalo, NY	Inorganic chemicals
	Syracuse, NY	Monochlorobenzene, o-dichlorobenzene
	Hopewell, VA	Organic chemicals
	Moundsville, WV	Toluene diisocyanate, methylene dianiline
Amerada Hess	a	Refinery products
American Aniline	a	b
American Color and Chemical	Lockhaven, PA	Dyes
American Cyanamid	Bound Brook, NJ	Organic chemicals
Atlantic Richfield[c]	Carson, CA	Refinery products
Atlantic Richfield/ Polymers, Inc.	Monaca, PA	Diethylebenzene, divinyl benzene
BASF Wyandotte	Geismar, LA	Chlorine, hydrogen, sodium hydroxide
	Washington, NJ	Polypropxy ethers, polypropylene glycol
Beckman Instrument Co.	Porterville, CA	b
Borden, Inc.	Bainbridge, NY	Plastics and resins
British Petroleum Corp.[c]	Marcus Hook, PA	Refinery products
C. M. Masland	Waskefield, RI	Textiles
Ciba Geigy	St. Gabriel, LA	Pesticides

TABLE 7-2 (Continued)

Crompton and Knowles Corp.	Gibraltar, PA	Dyes
Diamond Shamrock	Houston, TX	Pesticides
Dow Chemical	Gales Ferry, CT	Plastics and resins
	Plaquemine, LA	Organic chemicals
	Midland, MI	Phenol, acetic acid
Du Pont	Beaumont, TX	Pharmaceutical chems.
	Richmond, Va	Textile fibers
	Belle, WV	Organic chemicals
EPA Emergency Response Unit	Mobile Unit	Chemical spill cleanup
Fike Chemical	Nitro, WV	Speciality organic chemicals
First Chemical Corp.	Pascagoula, MS	Aniline, nitrobenzene, nitrotoluene
FMC	Baltimore, MD	Pesticides
	So. Charleston, WV	Organic chemicals
	Nitro, WV	Organic chemicals
	Middleport, NY	Pesticides
	Bayport, TX	Plasticizers, glycerin
General Electric	Pittsfield, MA	Plasticss and resins
	Fort Edwards, NY[d]	
	Selkirk, NY	Plastics and resins
Georgia Pacific	Conway, NC	Phenolic resins
Hardewicke chemical	Elgin, SC	Specialty organic chemicals
Hercules, Inc.	Hattiesburg, MS	Terpen oils, hydrocarbon resins
Hooker	Hahnville, LA	
Houston Chem. Div. of PPC	Beaumont, TX	Ethylene glycol, ethylene dibromide
ICI Americas	Goldsboro, NC	Pesticide research
Iowa Army Ammunition Plant	Burlington, IA	Explosives
Joliet Army Ammunition Plt	Joliet, IL	Explosives
Kansas Army Ammunition Plt	Parsons, KS	Explosives

TABLE 7-2 (Continued)

Liquified Coal Development Corp.	Captina, WV	Anthracene-derived solvents
Lone Star Army Ammunition Plant	Texarkana, TX	Explosives
Louisiana Army Ammunition Plant	Shreveport, LA	Explosives
Matlack	Swedesboro, NJ	Tank truck washing
Mobay	Cedar Bayou, TX	Organic chemicals
	New Martinsville, WV	Isocyanates, polyols, polyesters
Monsanto	Anniston, AL	Polynitrophenol
	Sauget, IL	Organic chemicals
	St. Louis, MO	Organic chemicals
	Alvin, TX	Organic chemicals
	Texas City, TX	Organic chemicals
	Luling, LA	Cyclohexanol
	Nitro, WV	Pesticides
Neville Chemical	Neville Island, PA	Plastics, resins
Olin Corp.	McIntosh, AL	Pesticides
	Bradenberg, KY	Organic chemicals
	Rochester, NY	Organic chemicals
	Ashtabula, OH	Organic chemicals
Owens Corning	Anderson, SC	Plastics and resins
Palisades Industries	Peace Dale, RI	Textiles
Pennwalt	Houston, TX	Organic chemicals
Pfizer Chemical	Terrahaute, IN	Pharamaceutical chems.
	South Port, NC	Citric acid
	Brooklyn, NY	Organic chemicals
	Greensboro, NC	Organic chemicals
Proctor and Gamble	Chicago, IL	Fatty acids
	Baltimore, MD	Fatty acids
	Kansas City, KS	Fatty acids, alcohols
	Dallas, TX	Fatty acids
Reichhold Chemicals	Tuscaloosa, AL	Phenol, pentaerythritol, resins
Republic Steel	Cleveland, OH	Coke

TABLE 7-2 (Continued)

Rhodia (Rhone-Poulenc)	Freeport, TX[c]	Organic chemicals
	Portland, OR	Pesticides
Rocky Mountain Arsenal	Denver, CO	b
Rogers Corporation	Manchester, CT	Plastics and resins
SCA Chemical Waste Services	Lewiston, NY	Chemical waste disposal
Schenectady Chemical	Schenectady, NY	Phenolic resins
Sherwin Williams Co.	Chicago, IL	Para-cresol
Stauffer Chemical	Bucks, AL[d]	
	Lemoyne, AL	Sulfur
	Richmond, CA	Pesticides
	Dominguez, CA	Inorganic chemicals
	San Jose, CA	Flavor and fragrance chemicals
	Delaware City, DE	Carbon disulfide
	Louisville, KY	Organic chemicals
	Geismar, LA[d]	
	Henderson, WV	Organic chemicals
	Skaneateles Falls,NY	Detergents
	Galliopolis Ferry,WV	Syn. lubricants, plasticizers, esters
	Green River, WY[d]	
Stepan Chemical	Fieldsboro, NJ	Detergent intermediates
Stephen-Leedom Carpet	Southhampton, PA	Carpets
Tooele Army Ammunition Plt	Tooele, UT	Explosives
TRA	Irving, TX	b
Union Carbide	Hahnville, LA[d]	
	Ponce, PR[d]	
	Greenville, SC	Synthetic fibers
	Woodbine, GA[d]	

TABLE 7-2 (Continued)

Velvet Textile Co.	Blackstone, VA	Textiles
Vicksburg Chemical	Vicksburg, MS	Toxaphene, methyl parathion
Yorktown Naval Weapons Sta.	Yorktown, VA	Explosives
Unidentified (1)[c]		Pesticides
Unidentified (2)		Organic chemcials
Unidentified (3)		Explosives
Unidentified (4)		Chlorobenzene, dichlorobenzene
Unidentified (5)		Toxaphne, DNBP, cyanazine
Unidentified (6)		Dalpon
Unidentified (7)		2,4-D, 2,4-DB, MCPA
Unidentified (8)		Parachloronitrobenzene, terrazole
Unidentified (9)		Dicofol
Unidentified (10)		Trifluralin, isopropanol, ethalfluralin
Unidentified (11)		DEET, piperonyl butoxide, thanite
Unidentified (12)		Carbofuran
Unidentified (13)		Atrazine

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[a] Location not given in data source.
[b] Information incomplete.
[c] Unit known to be shut down.
[d] No plant listed at this location in 1979 Directory of Chemical Producers.
[e] Neither company nor location identified in data source.

membrane processes such as reverse osmosis and ultrafiltration. These technologies are normally employed by industry as in-plant treatment; however, none were reported in the Summary Data Base.

Steam Stripping

Steam stripping is a variation of distillation whereby steam is used as both the heating medium and the driving force for the removal of volatile materials. For employment of steam stripping, steam is introduced into the bottom of a tower. As it passes through the wastewater, the steam vaporizes and removes volatile materials from the waste and then exits via the top of the tower. Although most commonly employed as an inplant technology for solvent recovery, steam stripping has been reported as a wastewater treatment process. Data from three plants using steam stripping as the primary treatment step are summarized in Table 7-3.

Liquid-Liquid Extraction

Liquid-liquid extraction (LLE) is a process that can separate certain components from a solution by contacting the solution with an immiscible liquid that has a higher solubility for the components of the solution than it does for the solution contacted. LLE operating and capital expenses involve the liquid-liquid contactor with its peripheral equipment and the solvent regeneration equipment. Although liquid-liquid extraction is a common process operation, it is normally applied as an in-plant treatment to utilize the highest available concentration gradient.

No data were available for LLE.

Oxidation

Oxidation as a treatment practice is accomplished by either wet or chemical oxidation. Wet oxidation is a common process in which an aqueous waste can be oxidized in a closed, high-temperature, high-pressure vessel. Wet oxidation has been used to treat a variety of wastes including pulping waste and acrylonitrile liquor. A percent reduction in excess of 99.8 has been reported for some of the toxic pollutants.[7-2] This process is applicable particularly as in-plant and EOP treatments of wastes with a high organic content.

The application of chemical oxidation to industrial wastes is well established for cyanides, sulfide, ammonia, and other such harmful substances in waste streams. Chemicals commonly used as oxidizing agents include chlorine, hypochlorite, hydrogen peroxide, potassium permanganate, ozone, and chlorine dioxide. Although several plants in the Summary Data Base reported using chlorination as part of their EOP treatment, it was used as a sterilizing medium rather than as a chemical oxidation process.

No data were available for oxidation.

TABLE 7-3

STEAM STRIPPING, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 3

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	0.546	238.0	288.0	84.9	1190.0	140.0	98.5	.	.	.	.	.	.
MEAN	0.375	238.0	112.0	84.9	641.5	61.3	84.0	.	.	.	.	.	.
MINIMUM	0.280	238.0	12.0	84.9	85.0	18.0	69.4	.	.	.	.	.	.
MEDIAN	0.300	238.0	36.0	84.9	641.5	26.0	84.0	.	.	.	.	.	.
NUMBER OF OBSERVATIONS	3	1	3	1	2	3	2	0	0	0	0	0	0

STEAM STRIPPING, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 3

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	492.0	360.0	87.6	.	.	.	.	.	.	.	.	.
MEAN	492.0	145.3	87.6	.	.	.	.	.	.	.	.	.
MINIMUM	492.0	15.0	87.6	.	.	.	.	.	.	.	.	.
MEDIAN	492.0	61.0	87.6	.	.	.	.	.	.	.	.	.
NUMBER OF OBSERVATIONS	1	3	1	0	0	0	0	0	0	0	0	0

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

END-OF-PIPE TREATMENT

End-of-pipe treatment refers to those processes that treat a combined plant waste stream for pollutant removal prior to discharge. Adequately designed, operated, and maintained EOP facilities allow manufacturers to discharge their wastewater directly to a receiving body of water.

EOP technologies covered in this report are classified as primary, secondary and tertiary processes. Depending on the nature of the pollutants to be removed and the degree of removal required, different combinations of the available treatment technologies may be used.

Primary treatment usually involves physical separation processes. These technologies include clarifiers, oil skimmers, dissolved air flotation and similar devices which may use flocculants to assist in the removals. Depending on the nature of the suspended solids in the wastewater, this treatment may remove a significant amount of the BOD attributable to suspended solids or floating materials from industrial wastewaters.

Secondary treatment is utilized when the primary system cannot improve the wastewater to a sufficient degree to permit discharge. Secondary treatment usually consists of biological processes capable of removing the soluble pollutant constituents. Biological processes are widely used in industrial waste treatment and, as measured by BOD, are very successful in removing biodegradable organics. Factors which influence the design and operation of biological systems for industrial wastes include the sensitivity of these systems to influent composition changes and the potential inhibitory effects of certain industrial chemicals on the microorganisms. Design techniques which accommodate such factors are discussed in the section entitled "Design, Operation and Management Practices."

Tertiary treatment refers to treatment following the biological or other secondary treatment system. The technologies available for tertiary treatment vary, but normally relate to the removal of specific pollutant parameters not effectively removed in secondary treatment. Some tertiary treatment unit processes are also applicable to in-plant or primary treatment schemes.

Primary Treatment

In the following paragraphs the primary treatment processes used by the 291 OCPS industry plants in the engineering data base are discussed.

Equalization - Equalization consists of a wastewater holding vessel or pond large enough to dampen flow and/or pollutant concentration variation and permit a nearly constant discharge rate and wastewater quality. The holding tank or pond capacity is determined by wastewater volume and composition variability. The equalization basin may be agitated or may utilize a baffle system to prevent short circuiting. Equalization is employed prior to wastewater treatment processes that are sensitive to fluctuations in waste composition or flow. No plants in the Summary Data Base reported equalization as the only treatment technology used.

However, 124 plants included equalization as a part of their total treatment system.

Neutralization - Neutralization is practiced in industry to raise or lower the pH of a wastewater stream. Alkaline wastewaters may be neutralized with hydrochloric acid, carbon dioxide, sulfur dioxide, and, most commonly, sulfuric acid. Acidic wastewaters may be neutralized with limestone or lime slurries, soda ash, caustic soda, or anhydrous ammonia. Often a suitable pH can be achieved through the mixing of acidic and alkaline process wastewaters. Selection of neutralizing agents is based on cost, availability, ease of use, reaction by-products, reaction rates, and quantities of sludge formed.

Nine plants in the 291 plant Summary Data Base reported using neutralization as their principal treatment method. In addition, 104 other plants used neutralization as part of their treatment system.

Clarification - Clarification, in this context, may be defined as the removal of solid particles from a wastewater through gravity settling. The nature of the solids and their concentration are the major factors affecting the settling properties.

Among plants in the Summary Data Base, eight employ clarification as the principal component of their treatment system. Performance data for these plants is presented in Table 7-4. In addition, 94 other plants use some form of clarification as part of their treatment system, either with or without the use of precipitation, coagulation or flocculation.

Precipitation/Coagulation/Flocculation - Gravity clarification may be supplemented by precipitation, coagulation or flocculation providing enhanced suspended solids removal. Precipitation, coagulation or flocculation may also be used as a primary treatment step to protect biological secondary treatment processes from upset due to toxic metallic pollutants.

Simple clarification is usually accomplished with standard sedimentation tanks (either rectangular or circular). If additional solids removal, removal of colloidal solids, or removal of dissolved metallic ions is required, precipitation, coagulation or flocculation are added. Coagulation is usually accomplished by adding an appropriate chemical (alum, lime, etc.) followed by a rapid mix and finally a slow agitation to promote floc particle growth. A polymeric coagulant aid is sometimes used in these systems.

A total of 3 plants in the Summary Data Base report using precipitation, coagulation, or flocculation as the principal component of their treatment system. Data reported for these systems is presented in Table 7-5. A total of 15 plants use some form of coagulation as part of their treatment system.

Flotation - Flotation is used to remove oils and other suspended substances with densities less than that of water or, in the case of dissolved air flotation, particles that may be slightly heavier than water. As with conventional clarifiers, flocculants are frequently employed to

TABLE 7- 4

CLARIFICATION, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT: 10

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	3,700	572,0	115,0	82,7	170,0	90,0	92,4	1219,0	455,0	62,7	.	1,6	.
MEAN	0,867	190,0	49,8	48,5	82,3	23,6	51,5	475,5	165,6	28,4	.	1,0	.
MINIMUM	0,057	9,0	4,0	10,9	31,0	7,0	7,2	42,0	42,0	0,0	.	0,4	.
MEDIAN	0.344	89.5	37.0	52.0	64.0	14.5	53.2	320.5	58.0	25.4	.	1.0	.
NUMBER OF OBSERVATIONS	10	4	6	3	4	8	4	4	7	4	0	2	0

CLARIFICATION, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 10

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	143,0	118.0	17,5	.	.	.	.	.	.	1,5	0,3	99,2
MEAN	76,0	67,5	17,5	.	.	.	.	.	.	1,0	0,1	69,6
MINIMUM	9,0	17,0	17,5	.	.	.	.	.	.	0,5	0,0	40,0
MEDIAN	76,0	67.5	17,5	.	.	.	.	.	.	1,0	0.0	69,6
NUMBER OF OBSERVATIONS	2	2	1	0	0	0	0	0	0	2	3	2

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7- 5

PPT.,COAGULATION,FILTRATION, ALL WASTE STREAMS[a]

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT: 3

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	32,100	62.0	632.0	72.6	.	804.0	.	.	523.0	.	.	.	.
MEAN	13,973	62.0	324.5	72.6	.	406.0	.	.	523.0	.	.	.	.
MINIMUM	4,600	62.0	17.0	72.6	.	8.0	.	.	523.0	.	.	.	.
MEDIAN	5.220	62.0	324.5	72.6	.	406.0	.	.	523.0	.	.	.	.
NUMBER OF OBSERVATIONS	3	1	2	1	0	2	0	0	1	0	0	0	0

PPT.,COAGULATION,FILTRATION, ALL WASTE STREAMS[a]

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT: 3

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	.	276.0	.	.	0.1	.	.	782.0	.	.	0.8	.
MEAN	.	276.0	.	.	0.1	.	.	782.0	.	.	0.8	.
MINIMUM	.	276.0	.	.	0.1	.	.	782.0	.	.	0.8	.
MEDIAN	.	276.0	.	.	0.1	.	.	782.0	.	.	0.8	.
NUMBER OF OBSERVATIONS	0	1	0	0	1	0	0	1	0	0	1	0

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

enhance the efficiency of the flotation units. Although flotation is sometimes referred to in the context of dissolved air flotation, such other technologies as oil/liquid skimming and solids skimming are also flotation operations, and are sometimes an integral part of standard clarification.

For the one OCPS industry plant having flotation as its primary method of treatment, summary performance data is presented in Table 7-6. An additional 6 plants use flotation as a part of their total treatment system.

Secondary Treatment

Technologies classified as secondary treatment are generally biological processes and serve the primary function of removing dissolved carbonaceous pollutants as represented by BOD, COD, and TOC measurements. Biological systems may also be designed to remove some nitrogenous pollutants. Biological systems can remove limited amounts of heavy metals and refractory organic toxic chemicals through adsorption, biomass uptake and biodegradation, if properly acclimated to the waste. Nevertheless, these processes are usually designed to treat large quantities of dissolved carbonaceous wastes and any other pollutant removal or treatment is often incidental.

Biological Treatment - All biological treatment systems are designed to expose wastewater containing biologically degradable organic compounds to a suitable mixture of microorganisms, in a controlled environment which contains sufficient essential nutrients for the biological reaction to procede. Under these conditions the reduction of biologically assimilable pollutants will take place in a reasonably predictable manner. Biological treatment is based on the ability of mircoorganisms to utilize organic carbon as a food source. The treatment is classified as aerobic, anaerobic, or facultative. Aerobic treatment requires the availability of free dissolved oxygen for the bio-oxidation of the waste. Anaerobic treatment is intolerant of free dissolved oxygen and can utilize "chemically bound" oxygen (such as sulfates) in breaking down the organic material. Facultative organisms can function under aerobic or anaerobic conditions as the oxygen availability dictates.

Although the definitions of the processes are distinct, in practice both aerobic and anaerobic conditions may exist in the same treatment unit, depending on degree of aeration, degree of mixing, effects of photosynthesis, and other factors which contribute to the supply and distribution of oxygen to the treatment system. Facultative lagoons are designed to utilize both aerobic and anaerobic mechanisms as a means of reducing the net sludge production.

Biological treatment processes are widely used, and if properly designed and operated, are capable of high BOD removal efficiencies. Such systems given sufficient reaction time, can reduce the concentration of any degradable organic material to a very low concentration. Any organic material which will respond to the standard BOD test procedure is by definition a degradable substrate.

TABLE 7-6

DISSOLVED AIR FLOATATION, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 1

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	0.334	.	122.0	.	.	42.0	.	.	162.0	.	.	.	.
MEAN	0.334	.	122.0	.	.	42.0	.	.	162.0	.	.	.	.
MINIMUM	0.334	.	122.0	.	.	42.0	.	.	162.0	.	.	.	.
MEDIAN	0.334	.	122.0	.	.	42.0	.	.	162.0	.	.	.	.
NUMBER OF OBSERVATIONS	1	0	1	0	0	1	0	0	1	0	0	0	0

DISSOLVED AIR FLOATATION, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 1

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	.	62.0	.	.	0.3	.	.	.	.	.	2.0	.
MEAN	.	62.0	.	.	0.3	.	.	.	.	.	2.0	.
MINIMUM	.	62.0	.	.	0.3	.	.	.	.	.	2.0	.
MEDIAN	.	62.0	.	.	0.3	.	.	.	.	.	2.0	.
NUMBER OF OBSERVATIONS	0	1	0	0	1	0	0	0	0	0	1	0

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

It was previously noted in Section IV that properly designed and operated biological treatment systems will produce similar effluent BOD_5 concentrations even though influent BOD_5 concentrations may be significantly different. This is illustrated by Figures 7-1 and 7-2. These figures were prepared by plotting the lognormal frequency distribution of plants achieving various effluent BOD_5 concentrations. The criteria, as explained later in this section, for establishing that a plant was well designed and operated was defined by including data from only those plants which achieved 95 percent BOD_5 removal or which achieved effluent BOD_5 concentrations of 50 mg/l or less. Prior to graphing, the data was sorted by influent BOD_5 concentration into the four ranges shown in the figure. The minimum, maximum, and median values for each set of data are also shown. Figure 7-1 presents data from Plastics Only plants, Figure 7-2 presents the data from all other plants for which influent and effluent BOD_5 concentrations were available, and which met the criteria for being well designed and operated.

The figures illustrate that good effluent quality can be achieved over a wide range of influent concentrations. For the Plastics Only plants, median effluent BOD_5 varies between 9 and 21 mg/l although influents range over two orders of magnitude. For OCPS plants producing products other than Plastics Only, median effluent BOD_5 concentrations range from 10 to 20 mg/l for influent BOD_5 concentrations up to 1000 mg/l, and a median effluent BOD_5 of 44 mg/l for influents greater than 1000 mg/l. The higher median effluent obtained for influents greater than 1000 mg/l does not necessarily indicate that high strength influents are any less degradable than the lower strength influents previously presented. The three lower plots in Figure 7-2 represent a relatively narrow range of influent concentrations, specifically 0 to 1000 mg/l. The uppermost plot presents data from 19 plants with influent BOD concentrations which range from 1076 mg/l to 5710 mg/l. Because of the signifcantly wider range of influents in this group, the spread between minimum and maximum effluent values does not necessarily contradict the theoretical assumption that a similar limiting effluent concentration can be achieved. Although the 19 plants with influent BOD concentrations greater than 1000 mg/l generally achieve the highest percentage BOD removals, typically 96 to 98+ percent, they do not necessarily degrade the organic material to the maximum degree possible. Without access to the design basis for each of the 19 plants, it cannot be determined if the plant was designed to achieve the maximum removal possible by a biological system, or a specified level of treatment (i.e., some percentage of BOD reduction) which was judged adequate for a specific site.

Although most biological systems can ultimately reduce effluent BOD to similar limiting concentrations, the rate of reaction will depend on a variety of design considerations. These considerations do limit the direct transfer of design and operating conditions from one industrial plant to another although the chemical product lines may be similar. Techniques are available, however, to optimize design and operating conditions to ensure adequate treatment for all industry wastes.

Biological systems operate most efficiently under so called "steady state" conditions. Unfortunately, industrial wastewater is frequently found to be extremely variable in composition and concentration. Waste

FIGURE 7-1

BIOLOGICAL SYSTEMS - PLASTICS ONLY

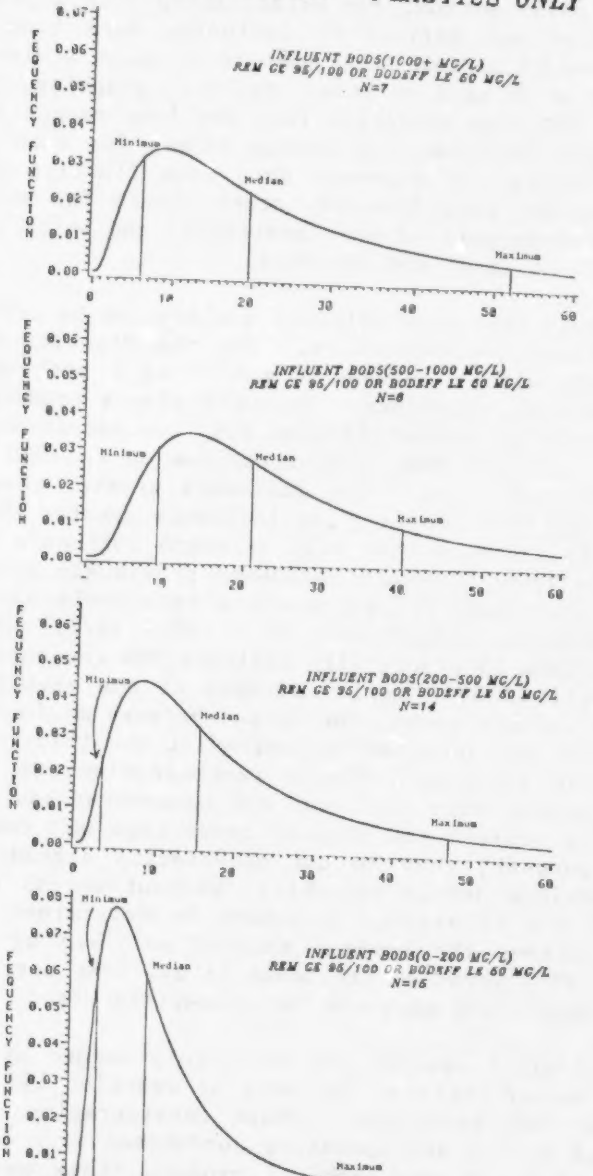
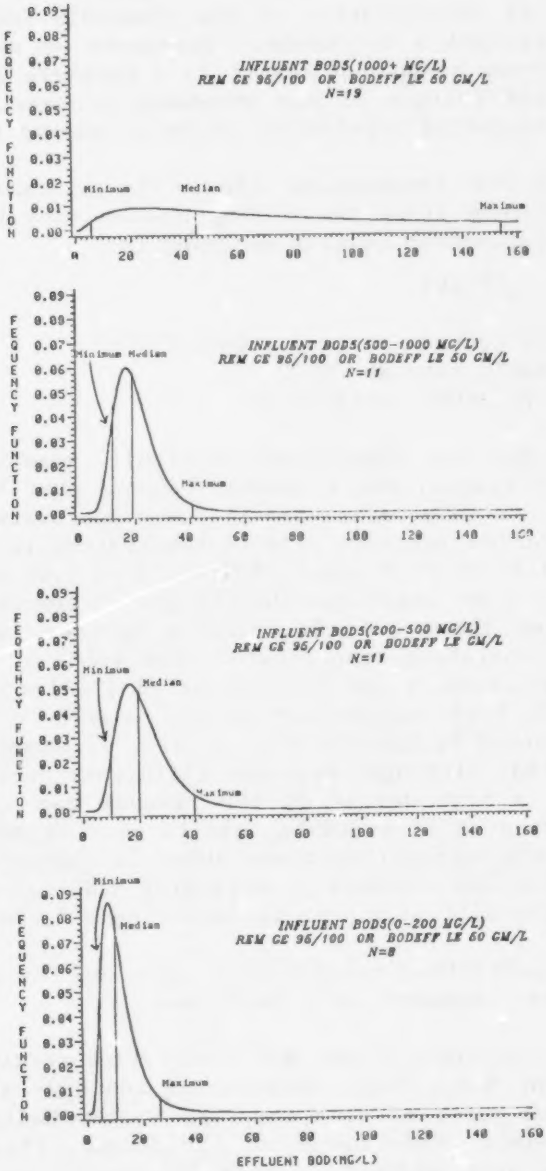


FIGURE 7-2

BIOLOGICAL SYSTEMS - NOT PLASTICS ONLY



equalization is typically used prior to biological treatment to address this consideration.

Toxic or inhibitory compounds frequently present in industrial wastes can impair the biological process. Proper acclimatization can develop strains of organisms which are tolerant to normally toxic substances. However, once a specialized strain is established, care must be exercised to avoid changes in concentration of the chemicals for which the microorganisms have developed a tolerance. Increases or decreases in concentration over a narrow range can result in a complete loss of the specialized organisms and failure of the treatment process. Reestablishment of a suitable microbial population can be a lengthy procedure.

It is generally accepted that temperature affects the performance of the biological treatment process since the biodegradation rate is temperature dependent. The relationship usually employed is:

$$k_T = k_{20^oC} \times \theta^{(T-20)}$$

where: k_T = kinetic rate at temperature T (^oC)
K_{20^o} = kinetic rate at 20(^oC)
θ = temperature coefficient

It should be recognized that the temperature of significance is the temperature in the reaction system, and a thermal balance must be computed considering the ambient air temperature and influent wastewater temperature. The sensitivity of the reaction rate to temperature is defined by θ, a dimensionless coefficient.* A value of θ equal to 1.00 would imply that the reaction kinetics are unaffected by changes in temperature. As the value of θ increases above 1.0 the reaction becomes increasingly sensitive to changes in operating temperature. The value of θ for several organic-chemical wastewaters has been reported [7-3] to vary from 1.055 to 1.10. The effect of temperature on BOD removal in an organic chemicals plant, as reported by Eckenfelder, et al., is shown in Figure 7-3. The figure shows that although treatment efficiency decreases with decreasing temperature, a high degree of BOD removal can be achieved even at very low temperatures if suitable food to microorganism ratios are maintained. Lower F/M ratios than those shown in Figure 7-3 can be used to obtain even higher BOD removals. Increasing MLSS concentrations and optimizing sludge ages will also help in improving BOD removals.

Other references show conflicting results in evaluating the effects of temperature on wastewater treatment plant performance.

Berthouex, et al. [7-4] developed linear and time series models relating effluent BOD_5 to influent BOD_5, MLSS, temperature and hydraulic retention time based on three years of data compiled at the Madison Sewage Treatment Plant (Wisconsin). They found no significant effect of temperature on performance when gradual changes in temperature (4-24°C) occurred.

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* which must be determined empirically

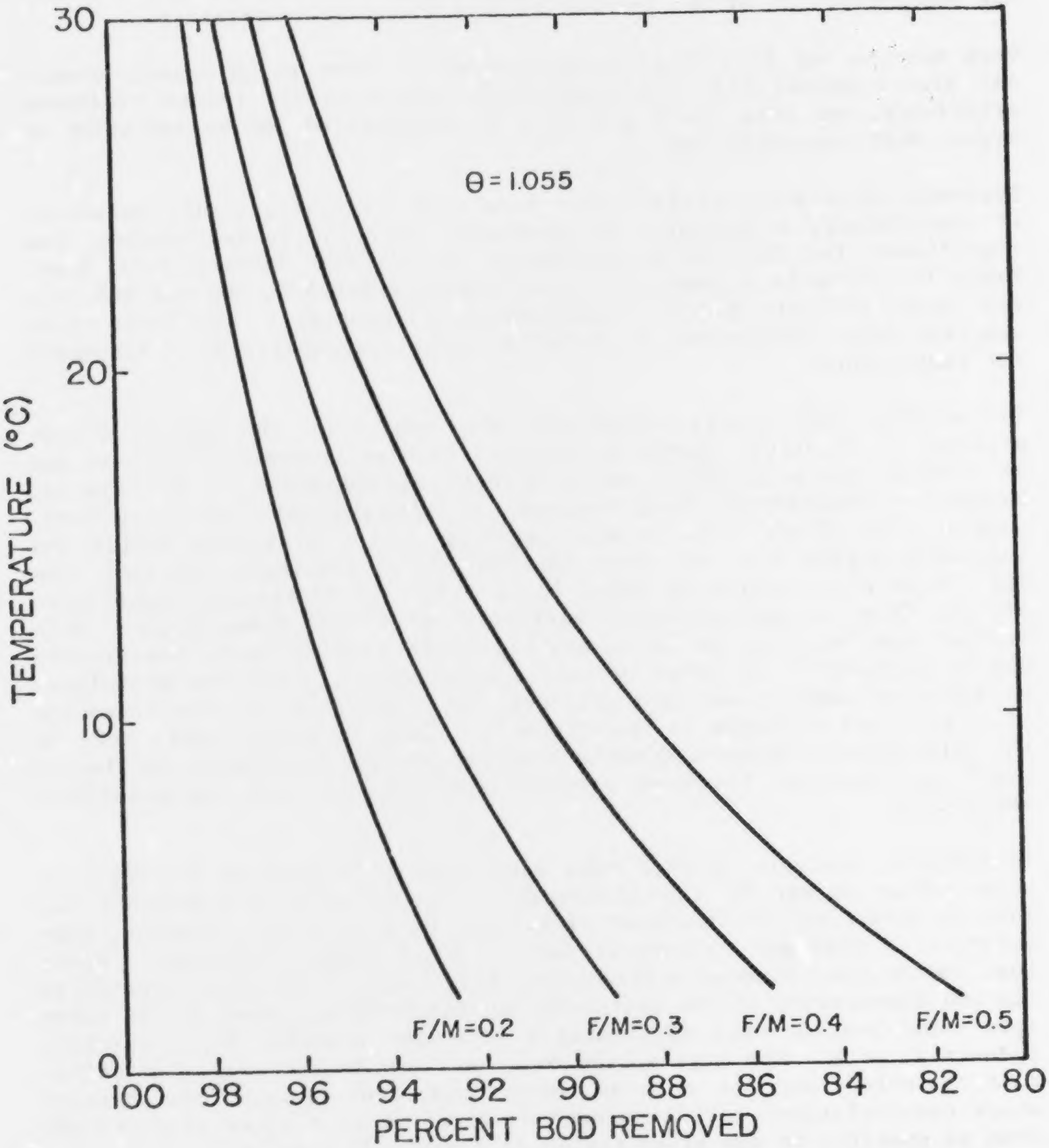

FIGURE 7-3. TEMPERATURE EFFECT ON EFFLUENT QUALITY

B.A. Sayigh [7-5] conducted activated-sludge laboratory studies with continuous stirred-tank reactors and concluded that the effects of temperature using domestic sewage, organic-chemicals wastewaters and petrochemical wastewaters depend on the specific type of wastewater being treated. The author also found that the higher the sludge age, the less the susceptibility of the process to variations in temperature.

Work done by Del Pino [7-6] using wastewaters from three organic chemical plants showed that low temperature operation did reduce treatment efficiency, but this could generally be compensated for by operation at higher MLSS concentrations.

Spearman correlation coefficients were used to statistically determine if temperature, as measured by geographic location in degree-days, was significant for biological effluents in the EGD Summary Data Base. Table 7-7 presents a summary of this analysis for BOD, COD and TSS. In all cases, effluent quality (measured as effluent mg/l) was found to be statistically independent of location using degree-days as a surrogate for temperature.

The principal difficulty encountered when evaluating the impact of temperature on treatment system performance is that temperature is only one of several characteristics which affect the operation of the system. Changes in temperature (both seasonal and short term), raw waste load, product mix, flow, food to microorganism ratio, dissolved solids and suspended solids will all have some impact on treatment. In reviewing full scale plant operating data, it is difficult to isolate temperature effects from changes caused by variables other than temperature. This problem can be overcome in laboratory scale studies where temperature can be controlled and other variables held constant, but the usefulness of applying temperature data collected in this manner to the operation of a full scale system is questionable. This is particularly true in the OCPS industry where raw waste load variability is significant due to batch operations, frequent product mix changes, and raw materials variations.

In summary, analysis of this data would generally confirm the observations which appear in the literature. Specifically, temperature can have an impact on the treatment efficiency in some cases. However, temperature is only one of several factors which impact treatment. Waste load variations, biomass acclimation, flow variations, waste treatability and temperature of the wastewater during treatment must all be taken into consideration when developing a treatment sequence for a specific industrial site. The interaction between these factors makes it difficult to isolate any one, such as temperature, separately. Thus, temperature considerations must be viewed as specific to a given site, rather than as specific to any given region or geographic area.

Regardless of the above restrictions and limitations on the applicability of biological treatment systems, technologies and operating techniques exist, which if properly applied, can overcome these limitations. Just as two organic chemical plants producing the same product may have different process chemistry which reflects differences in feedstocks, treatment systems must be designed and operated to reflect the specific

TABLE 7-7

DEGREE-DAYS VS. EFFLUENT QUALITY
SPEARMAN CORRELATION COEFFICIENTS FOR EFFLUENTS

Data Set	Coefficient		
	BOD	COD	TSS
PLASTICS ONLY	-0.13	0.10	0.04
ORGANICS ONLY	-0.04	-0.03	-0.10
PLASTICS AND ORGANICS	0.07	0.12	-0.21
ALL PLANTS	-0.06	0.03	-0.11

characteristics of the wastewater they process. By considering each wastewater stream to be treated individually, and judiciously selecting the optimum combination of source control, pretreatment and treatment technologies, treatment of OCPS wastewaters to very low effluent BOD levels will be possible in all but the most extreme cases. Specific means of mitigating temperature aspects are discussed later in this chapter.

Aerated Lagoons

Aerated lagoons are stabilization basins to which air is added either through diffusion or mechanical agitation. The air provides the oxygen required for aerobic biodegradation of the organic waste. In some designs the air addition will provide sufficient mixing to maintain the biological solids in suspension so that they can be removed in a secondary sedimentation tank. After settling, sludge may be recycled to the head of the lagoon. When operated in this manner, the aerated lagoon is an activated sludge process. The viable biological solids level in an aerated lagoon is normally low when compared to that of an activated sludge unit. The aerated lagoon relies primarily on detention time for the breakdown and removal or organic matter. Aeration periods of 3 to 8 days are common.

Twenty-seven of the 291 plants included in the Summary Data Base reported using aerated lagoon treatment. A summary of the performance of these plants is presented in Tables 7-8 thru 7-12.

Aerobic Lagoons

Aerobic lagoons are shallow ponds which contain bacteria and algae in suspension, with aerobic conditions prevailing throughout the depth of the basin. Waste is stabilized as a result of the symbiotic relationship between aerobic bacteria and algae. Supplemental oxygen is provided through natural reaeration. Bacteria break down waste and generate carbon dioxide and nutrients (primarily nitrogen and phosphorus). Algae in the presence of sunlight utilize the nutrients and inorganic carbon and, in turn, supply oxygen that is utilized by aerobic bacteria. Aerobic lagoons are usually less than 4-6 feet deep and can be periodically mixed to maintain their aerobic conditions. Algae do not settle well using conventional clarification. In order to achieve effective pollutant removals with aerobic lagoons, some means of removing algae (coagulation, filtration, multiple-cell design) is sometimes necessary.

A total of four OCPS industry plants use aerobic lagoons as the principal component of their treatment system. A performance summary for these four plants is presented as Table 7-13.

Anaerobic Lagoons

An anaerobic lagoon is deoxygenated throughout its depth and has the advantages of low sludge production and operating costs. Treatment results from a combination of precipitation and anaerobic decomposition of organics, initially to organic acids and cell tissue, and ultimately to carbon dioxide, methane and other gaseous end products. Anaerobic

TABLE 7-8

AERATED LAGOON, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 27

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	19.900	1137.0	279.0	98.4	2686.0	395.0	98.7	21178	1178.0	98.8	570.0	112.0	80.4
MEAN	3.158	479.8	54.9	90.2	550.8	62.6	51.2	4229.5	276.4	82.4	570.0	30.5	80.4
MINIMUM	0.008	94.0	7.0	65.8	23.0	2.0	-56.5	120.0	30.0	66.5	570.0	1.0	80.4
MEDIAN	0.812	514.5	15.0	91.0	285.0	33.0	61.1	1327.0	135.0	83.5	570.0	11.5	80.4
NUMBER OF OBSERVATIONS	26	10	21	10	11	22	11	11	19	10	1	6	1

AERATED LAGOON, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 27

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	2056.0	133.0	88.1	2395.0	14.0	99.7	19.0	240.0	80.5	0.4	1.3	54.6
MEAN	503.7	48.1	61.9	954.1	4.3	99.5	10.4	54.4	52.7	0.4	0.3	54.6
MINIMUM	20.0	14.0	25.0	2.5	0.0	99.2	1.8	1.1	22.2	0.4	0.1	54.6
MEDIAN	332.0	34.0	63.9	709.5	0.8	99.6	10.4	3.7	54.0	0.4	0.2	54.6
NUMBER OF OBSERVATIONS	7	7	6	4	6	3	4	7	4	1	8	1

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7-9

AERATED LAGOON, PLASTICS ONLY[a]

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT: 8

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	5.950	447.0	86.0	90.4	643.0	38.0	97.0	531.0	334.0	84.0	.	14.0	.
MEAN	1.216	220.0	28.1	89.0	643.0	18.5	97.0	355.0	126.0	77.2	.	7.5	.
MINIMUM	0.167	94.0	7.0	88.2	643.0	11.0	97.0	179.0	30.0	70.4	.	1.1	.
MEDIAN	0.684	119.0	15.0	88.3	643.0	15.0	97.0	355.0	104.5	77.2	.	7.5	.
NUMBER OF OBSERVATIONS	8	3	7	3	1	6	1	2	6	2	0	2	0

AERATED LAGOON, PLASTICS ONLY[a]

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT: 8

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	.	.	.	.	0.1	.	.	.	.	.	0.4	.
MEAN	.	.	.	.	0.1	.	.	.	.	.	0.4	.
MINIMUM	.	.	.	.	0.1	.	.	.	.	.	0.4	.
MEDIAN	.	.	.	.	0.1	.	.	.	.	.	0.4	.
NUMBER OF OBSERVATIONS	0	0	0	0	1	0	0	0	0	0	1	0

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[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7-10

AERATED LAGOON, NOT PLASTICS (TYPE I & C)

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT: 9

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	15.800	823.0	251.0	98.4	665.0	395.0	61.1	21178	1178.0	98.8	*	9.0	*
MEAN	3.210	534.7	72.3	87.2	214.6	121.4	17.2	9239.0	413.9	89.3	*	9.0	*
MINIMUM	0.008	199.0	7.0	65.8	23.0	20.0	-56.5	1327.0	138.0	81.1	*	9.0	*
MEDIAN	1.010	582.0	41.0	97.4	73.0	62.0	25.9	7225.5	256.0	88.7	*	9.0	*
NUMBER OF OBSERVATIONS	9	3	7	3	8	9	5	4	7	4	0	1	0

AERATED LAGOON, NOT PLASTICS (TYPE I & C)

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 9

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	513.0	64.0	88.1	974.0	1.4	99.7	19.0	125.0	80.5	0.4	1.3	54.6
MEAN	288.3	46.7	64.6	709.5	0.7	99.7	15.5	34.0	65.3	0.4	0.4	54.6
MINIMUM	20.0	15.0	25.0	445.0	0.0	99.7	12.0	1.1	50.0	0.4	0.1	54.6
MEDIAN	332.0	61.0	80.7	709.5	0.7	99.7	15.5	4.8	65.3	0.4	0.2	54.6
NUMBER OF OBSERVATIONS	3	3	3	2	2	1	2	4	2	1	5	1

* I Type I w/oxidation

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7-11

AERATED LAGOON, NOT PLASTICS (TYPE I NOT C)*

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 4

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	3,600	1137,0	80,0	98,0	2686,0	62,0	98,7	5546,0	354,0	96,5	570,0	112,0	80,4
MEAN	1,288	813,0	37,8	93,8	1390,3	31,0	94,9	2148,3	141,3	82,0	570,0	56,5	80,4
MINIMUM	0,030	647,0	11,0	87,6	494,0	13,0	87,4	120,0	30,0	66,7	570,0	1,0	80,4
MEDIAN	0,762	655,0	30,0	95,9	991,0	24,5	98,7	1463,5	40,0	82,9	570,0	56,5	80,4
NUMBER OF OBSERVATIONS	4	3	4	3	3	4	3	4	3	3	1	2	1

AERATED LAGOON, NOT PLASTICS (TYPE I NOT C)*

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 4

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	2056,0	14,0	.	2,5	14,0	99,2	1,8	1,4	22,2	.	0,1	.
MEAN	2056,0	14,0	.	2,5	7,0	99,2	1,8	1,4	22,2	.	0,1	.
MINIMUM	2056,0	14,0	.	2,5	0,0	99,2	1,8	1,4	22,2	.	0,1	.
MEDIAN	2056,0	14,0	.	2,5	7,0	99,2	1,8	1,4	22,2	.	0,1	.
NUMBER OF OBSERVATIONS	1	1	0	1	2	1	1	1	1	0	1	0

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

* Type 1 w/o Oxidation

TABLE 7-12

AERATED LAGOON, NOT PLASTICS (NOT TYPE I)

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 6

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	19.900	95.0	279.0	91.6	138.0	32.0	89.1	266.0	1045.0	66.5	.	46.0	.
MEAN	7.665	95.0	99.7	91.6	86.0	16.3	47.5	266.0	391.3	66.5	.	46.0	.
MINIMUM	0.008	95.0	8.0	91.6	34.0	2.0	5.9	266.0	40.0	66.5	.	46.0	.
MEDIAN	4.090	95.0	12.0	91.6	86.0	15.0	47.5	266.0	89.0	66.5	.	46.0	.
NUMBER OF OBSERVATIONS	5	1	3	1	2	3	2	1	3	1	0	1	0

AERATED LAGOON, NOT PLASTICS (NOT TYPE I)

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 6

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	502.0	133.0	73.5	2395.0	10.0	99.6	8.8	240.0	58.0	.	0.1	.
MEAN	201.7	61.0	59.3	2395.0	10.0	99.6	8.8	121.8	58.0	.	0.1	.
MINIMUM	35.0	16.0	50.0	2395.0	10.0	99.6	8.8	3.7	58.0	.	0.1	.
MEDIAN	68.0	34.0	54.3	2395.0	10.0	99.6	8.8	121.8	58.0	.	0.1	.
NUMBER OF OBSERVATIONS	3	3	3	1	1	1	1	2	1	0	1	0

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7-13

AEROBIC LAGOON, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 5

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	3.320	78.0	42.0	88.5	.	37.0	.	.	252.0	.	.	8.0	.
MEAN	1.479	78.0	17.6	88.5	.	16.4	.	.	168.5	.	.	8.0	.
MINIMUM	0.155	78.0	7.0	88.5	.	4.0	.	.	85.0	.	.	8.0	.
MEDIAN	1.500	78.0	10.0	88.5	.	16.0	.	.	168.5	.	.	8.0	.
NUMBER OF OBSERVATIONS	5	1	5	1	0	5	0	0	2	0	0	1	0

AEROBIC LAGOON, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 5

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	66.0	48.0	71.2	.	0.6	.	.	0.4	.	0.1	0.3	55.1
MEAN	66.0	33.5	71.2	.	0.4	.	.	0.4	.	0.1	0.1	55.1
MINIMUM	66.0	19.0	71.2	.	0.1	.	.	0.4	.	0.1	0.0	55.1
MEDIAN	66.0	33.5	71.2	.	0.4	.	.	0.4	.	0.1	0.0	55.1
NUMBER OF OBSERVATIONS	1	2	1	0	2	0	0	1	0	1	3	1

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

lagoons are constructed with depths to 20 feet and steep side walls to minimize surface area (relative to total volume) to allow a natural organism cover (pellicle) to form and help retain heat, suppress odor, and maintain anaerobic conditions. Wastewater enters near the bottom and the discharge point is located opposite and below the pellicle. Sludge recirculation is not necessary because gasification and the inlet-outlet flow pattern provide adequate mixing. Anaerobic lagoons are sometimes used to digest the waste sludge from an activated sludge plant. Anaerobic lagoons as a principal wastewater treatment technology are used at two plants in the 291 plant Summary Data Base. BOD removals greater than 90 percent were reported by these plants. Additional performance data is presented in Table 7-14.

Activated Sludge

Activated sludge is an aerobic biological process. Its basic processes include an aerated biological reactor, a clarifier for separation of biomass, and a piping arrangement to return separated biomass to the biological reactor. Aeration provides the necessary oxygen for aerobic biodegradation and mixing to maintain the biological solids in suspension.

Activated sludge process modifications commonly in use include conventional, step-aeration, tapered-aeration, modified-aeration, contact stabilization, complete-mix, extended-aeration and oxygen activated sludge. Activated sludge is the most common end-of-pipe treatment employed in the OCPS industry Summary Data Base. Of the 291 plants making up the data base, a total of 104 use activated sludge, treating 107 separate waste streams. Tables 7-15 thru 7-19 summarize the performance of these activated sludge plants by OCPS industry proposed subcategories.

Pure oxygen activated sludge was reported to be the principal treatment technology at three plants. A performance summary of these plants is presented in Table 7-20.

Attached Growth Biological Treatment

In attached growth biological systems the biomass adheres to the surfaces of rigid supporting media that contact the wastewater. Systems of this type that are in common use in the OCPS industry include trickling filters, packed towers and rotating biological contactors. While the physical structures differ, the biological process is essentially the same in all attached growth systems.

As wastewater contacts the supporting medium, a thin-film biological slime develops and coats the surfaces. The film consists primarily of bacteria, protozoa, and fungi that feed on the waste. As the slime grows, it separates or sloughs off. The sloughed biomass is then removed in a secondary clarifier.

Trickling filters are classified by hydraulic or organic loading as "low rate" or "high rate." Low-rate filters generally have a depth of six to ten feet and no recirculation. High-rate filters have a depth of three to ten feet and a recirculation rate of 0.5 to 4.0. High-rate filters

TABLE 7-14

ANAEROBIC, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 2

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	12,200	970,0	22,0	97,7	.	86,0	.	2189,0	147,0	93,3	.	.	.
MEAN	8,225	644,5	20,5	95,9	.	86,0	.	1121,0	87,5	70,2	.	.	.
MINIMUM	4,250	319,0	19,0	94,0	.	86,0	.	53,0	28,0	47,2	.	.	.
MEDIAN	8.225	644,5	20.5	95,9	.	86.0	.	1121.0	87,5	70.2	.	.	.
NUMBER OF OBSERVATIONS	2	2	2	2	0	1	0	2	2	2	0	0	0

ANAEROBIC, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 2

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	695,0	74,0	89,4	.	.	.	.	.	.	.	.	.
MEAN	411,5	51,0	83,7	.	.	.	.	.	.	.	.	.
MINIMUM	128,0	28,0	78,1	.	.	.	.	.	.	.	.	.
MEDIAN	411,5	51.0	83,7	.	.	.	.	.	.	.	.	.
NUMBER OF OBSERVATIONS	2	2	2	0	0	0	0	0	0	0	0	0

[a] These data are from plantsthat use this technology as the principal component of their wastewater treatment system.

TABLE 7-15

ACTIVATED SLUDGE, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 107

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	40.000	5961.0	780.0	99.7	4110.0	851.0	90.2	32476	11000	98.3	242.0	80.0	98.7
MEAN	2.472	1216.6	37.4	93.4	512.9	69.1	43.3	3080.8	459.2	81.3	58.1	10.8	59.3
MINIMUM	0.008	14.0	3.0	47.5	17.0	7.0	-271.4	210.0	36.0	18.1	16.0	0.6	12.6
MEDIAN	1.070	754.0	26.0	95.6	116.0	45.0	62.9	1686.0	186.0	86.9	23.0	6.0	67.6
NUMBER OF OBSERVATIONS	107	85	101	85	54	90	54	73	79	70	7	17	6

ACTIVATED SLUDGE, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 107

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	5226.0	685.0	99.5	747.0	36.0	100.0	390.0	274.0	93.8	2.3	10.0	97.2
MEAN	1025.8	123.2	80.7	145.6	2.3	92.2	75.3	33.4	10.9	0.6	0.6	-80.2
MINIMUM	67.0	7.0	36.5	0.1	0.0	61.5	0.8	0.4	-347.4	0.0	0.0	-1329
MEDIAN	505.0	69.0	89.6	14.3	0.1	94.7	30.0	6.9	27.0	0.2	0.1	73.6
NUMBER OF OBSERVATIONS	29	29	24	18	28	18	23	40	22	12	21	11

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7-16

ACTIVATED SLUDGE, PLASTICS ONLY

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 40

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	10.700	3520.0	58.0	99.7	2898.0	179.0	99.2	4338.0	620.0	98.1	242.0	80.0	73.9
MEAN	1.638	616.8	17.8	94.3	503.1	44.6	52.1	1302.1	128.8	84.8	102.0	15.5	69.7
MINIMUM	0.034	14.0	3.0	78.1	22.0	7.0	-45.5	210.0	36.0	48.2	23.0	1.2	66.9
MEDIAN	0.683	390.0	10.5	96.5	101.0	30.0	66.0	900.0	97.0	89.0	41.0	7.0	68.3
NUMBER OF OBSERVATIONS	40	35	38	35	31	39	31	33	34	31	3	8	3

ACTIVATED SLUDGE, PLASTICS ONLY

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 40

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	2751.0	96.0	99.5	426.0	0.5	100.0	49.0	109.0	89.6	2.0	0.3	97.2
MEAN	1103.4	48.2	86.7	71.6	0.1	86.5	16.5	22.8	-27.0	0.6	0.1	53.5
MINIMUM	290.0	15.0	66.9	0.1	0.0	61.5	2.0	0.4	-347.4	0.1	0.0	-50.0
MEDIAN	464.0	43.5	90.3	0.1	0.0	92.4	8.0	6.0	25.0	0.2	0.0	83.4
NUMBER OF OBSERVATIONS	5	6	4	6	9	6	10	16	9	4	7	4

[a] These data are from plantsthat use this technology as the principal component of their wastewater treatment system.

TABLE 7-17

ACTIVATED SLUDGE, NOT PLASTICS (TYPE I & C)

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT[a]: 42

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	29.000	8961.0	468.0	99.6	4110.0	235.0	98.9	9229.0	4079.0	98.1	17.4	15.2	12.6
MEAN	2.859	1976.8	86.0	93.0	628.5	84.2	26.7	4242.9	569.8	79.8	16.7	7.2	12.6
MINIMUM	0.008	153.0	6.0	47.8	28.0	9.0	-271.4	562.0	55.0	18.1	16.0	0.6	12.6
MEDIAN	1.125	1396.0	50.0	95.6	86.0	71.0	57.1	4016.0	336.5	80.5	16.7	6.5	12.6
NUMBER OF OBSERVATIONS	42	36	41	34	13	31	13	25	28	24	2	4	1

ACTIVATED SLUDGE, NOT PLASTICS (TYPE I & C)*

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT[a]: 42

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	3202.0	685.0	97.7	741.0	36.0	100.0	390.0	274.0	91.1	2.3	0.5	80.0
MEAN	1056.9	156.4	78.9	269.7	5.5	94.6	137.1	46.6	37.1	0.8	0.2	22.9
MINIMUM	268.0	23.0	36.5	1.6	0.0	80.0	2.4	1.8	-17.0	0.1	0.0	-66.7
MEDIAN	719.0	86.5	89.9	121.5	0.2	97.1	53.0	16.0	33.8	0.3	0.2	39.1
NUMBER OF OBSERVATIONS	15	14	13	8	11	8	9	17	9	5	8	4

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

* Type I w/ Oxidation

TABLE 7-18

ACTIVATED SLUDGE, NOT PLASTICS (TYPE I NOT C)*

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 15

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	4.310	2725.0	780.0	97.7	780.0	851.0	85.0	32476	11000	98.3	17.0	15.0	35.3
MEAN	1.533	1267.7	112.2	90.4	345.2	136.1	41.2	8883.4	1813.5	82.5	17.0	13.0	35.3
MINIMUM	0.020	66.0	11.0	70.8	133.0	18.0	-9.1	333.0	40.0	66.1	17.0	11.0	35.3
MEDIAN	1.440	1015.5	28.0	92.7	177.0	71.0	40.1	3449.0	357.5	79.1	17.0	13.0	35.3
NUMBER OF OBSERVATIONS	15	10	13	10	5	11	5	7	8	7	1	2	1

ACTIVATED SLUDGE, NOT PLASTICS (TYPE I NOT C)

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 15

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	5226.0	501.0	97.5	18.0	1.0	99.1	233.0	80.0	93.8	.	0.4	.
MEAN	1144.1	131.5	80.4	14.3	0.7	95.8	132.5	28.2	79.7	.	0.4	.
MINIMUM	67.0	7.0	48.4	10.7	0.2	92.6	32.0	1.8	65.7	.	0.4	.
MEDIAN	431.0	79.0	79.7	14.3	0.8	95.8	132.5	15.5	79.7	.	0.4	.
NUMBER OF OBSERVATIONS	7	8	7	2	3	2	2	4	2	0	1	0

* Type I w/o Oxidation

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7-19

ACTIVATED SLUDGE, NOT PLASTICS[a] (NOT TYPE I)

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT: 10

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	40.000	520.0	27.0	97.0	1266.0	101.0	97.3	5488.0	413.0	98.0	50.0	3.0	98.7
MEAN	5.598	323.2	15.6	95.5	437.0	41.2	33.7	1709.3	159.2	78.6	50.0	1.5	98.7
MINIMUM	0.335	162.0	3.0	91.5	17.0	18.0	-70.6	218.0	65.0	44.5	50.0	0.7	98.7
MEDIAN	1.445	324.0	14.0	96.1	121.0	29.0	35.5	642.0	111.0	71.5	50.0	0.8	98.7
NUMBER OF OBSERVATIONS	10	6	9	6	8	9	5	8	9	8	1	3	1

ACTIVATED SLUDGE, NOT PLASTICS (NOT TYPE I)[a]

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT: 10

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	194.0	41.0	.	4.0	0.2	96.9	65.6	64.1	2.3	0.7	10.0	90.5
MEAN	184.5	41.0	.	2.2	0.1	95.9	33.2	22.4	-5.1	0.3	2.1	-396.0
MINIMUM	175.0	41.0	.	0.3	0.0	95.0	0.8	0.9	-12.5	0.0	0.0	-1329
MEDIAN	184.5	41.0	.	2.2	0.1	95.9	33.2	2.2	-5.1	0.2	0.1	50.0
NUMBER OF OBSERVATIONS	2	1	0	2	5	2	2	3	2	3	5	3

a These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7-20

Pure Oxygen Activated Sludge

ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 3

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	7,160	467,0	26,0	97,2	204,0	38,0	94,1	345,0	105,0	85,2	.	.	.
MEAN	3,830	270,0	18,7	90,0	131,0	25,0	64,3	322,5	78,0	75,1	.	.	.
MINIMUM	0,950	143,0	13,0	87,0	58,0	12,0	34,5	300,0	51,0	65,0	.	.	.
MEDIAN	3.380	200.0	17.0	88.1	131.0	25.0	64.3	322.5	78.0	75.1	.	.	.
NUMBER OF OBSERVATIONS	3	3	3	3	2	2	2	2	2	2	0	0	0

Pure Oxygen Activated Sludge

ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 3

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	75,0	26,0	65,3	8,3	0,4	99,0	.	.	.	.	.	.
MEAN	75,0	26,0	65,3	5,1	0,2	96,8	.	.	.	.	.	.
MINIMUM	75,0	26,0	65,3	2,0	0,0	94,7	.	.	.	.	.	.
MEDIAN	75.0	26.0	65.3	5.1	0.2	96.8	.	.	.	.	.	.
NUMBER OF OBSERVATIONS	1	1	1	2	2	2	0	0	0	0	0	0

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[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

can be single or two stage. The most suitable medium in both the low and high-rate filters is crushed rock.

In the OCPS 291 plant Summary Data Base three plants reported using trickling filters as their principal technology for EOP treatment. A performance summary for these three plants is presented as Table 7-21.

Packed towers are much like conventional trickling filters, but use a manufactured medium instead of crushed rock or gravel. The manufactured medium can be corrugated plastic packing or rough-sawn redwood slats. These media have high specific surfaces (ft^2/ft^3), a high percentage of void volume, uniformity for better liquid distribution, chemical resistance, light weight facilitating construction of deeper beds, and the ability to handle high-strength and unsettled wastewaters. Packed towers are used in flow patterns similar to normal high-rate, natural-media filter systems.

In rotating biological contactor systems a series of disks constructed of corrugated plastic plate and mounted on a horizontal shaft are placed in a contour-bottomed tank and immersed to approximately 40 percent of the diameter. The disks rotate as wastewater passes through the tank and a fixed-film biological growth similar to that on trickling filter media adheres to the surface. Alternating exposure to the wastewater and the oxygen in the air results in biological oxidation of the organics in the wastes. Biomass sloughs off (as in the trickling filter and packed tower systems) and is carried out in the effluent for gravity separation. Direct recirculation is not generally practiced with the rotating biological disks.

Four plants in the OCPS Summary Data Base use rotating biological contactors as their principal form of treatment. All four of these plants are "plastics only" facilities. A summary of their performance is presented in Table 7-22.

Tertiary Treatment

In some instances, where secondary treatment does not produce a satisfactory effluent, polishing or tertiary treatment is utilized. The addition of a tertiary unit process does not always result in an effluent of higher quality than can be achieved with biological treatment. Often tertiary treatment is used to compensate for inadequately designed or improperly operated biological systems. Depending on the nature of the pollutant to be removed and the degree of removal required, the polishing or tertiary treatment system can consist of a one unit operation or multiple-unit operations in series. Some of the unit operations used in tertiary treatment may also be used as in-plant treatment options.

Polishing Ponds - Polishing ponds serve as polishing steps following other biological treatment processes. They primarily serve the purpose of reducing suspended solids. Water depth generally is limited to two or three feet. Polishing ponds are commonly used as a final process.

Powdered Activated Carbon Treatment - Powdered activated carbon treatment (PAC) refers to the addition of powdered carbon to the aeration

TABLE 7-21

TRICKLING FILTER, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT[a] 3

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	3.570	481.0	31.0	95.2	1225.0	55.0	95.5	1979.0	250.0	87.4	.	.	.
MEAN	1.731	310.0	26.0	90.0	627.5	34.0	76.1	1021.7	163.0	79.1	.	.	.
MINIMUM	0.423	170.0	23.0	85.9	30.0	13.0	56.7	210.0	63.0	70.0	.	.	.
MEDIAN	1.200	279.0	24.0	88.9	627.5	34.0	76.1	876.0	176.0	79.9	.	.	.
NUMBER OF OBSERVATIONS	3	3	3	3	2	2	2	3	3	3	0	0	0

TRICKLING FILTER, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT[a] 3

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	.	.	.	.	.	.	3.0	1.0	66.7	.	.	.
MEAN	.	.	.	.	.	.	3.0	1.0	66.7	.	.	.
MINIMUM	.	.	.	.	.	.	3.0	1.0	65.7	.	.	.
MEDIAN	.	.	.	.	.	.	3.0	1.0	66.7	.	.	.
NUMBER OF OBSERVATIONS	0	0	0	0	0	0	1	1	1	0	0	0

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

TABLE 7-22

ROTATING BIOLOGICAL CONTACTOR, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT[a]: 4

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	2,740	1200,0	52,0	95,7	49,0	43,0	25,0	2376,0	188,0	92,1	.	2,3	.
MEAN	0,904	434,0	30,5	80,4	34,5	29,3	18,6	859,8	99,0	73,5	.	2,3	.
MINIMUM	0,054	51,0	4,0	41,0	20,0	15,0	12,2	97,0	15,0	31,2	.	2,3	.
MEDIAN	0,411	242,5	33,0	92,5	34,5	30,0	18,6	483,0	96,5	85,4	.	2,3	.
NUMBER OF OBSERVATIONS	4	4	4	4	2	3	2	4	4	4	0	1	0

ROTATING BIOLOGICAL CONTACTOR, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR WASTEWATER TREATMENT[a]: 4

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	100,0	71,0	29,0	.	.	.	.	29,0	.	0,1	0,1	88,9
MEAN	100,0	71,0	29,0	.	.	.	.	29,0	.	0,1	0,1	88,9
MINIMUM	100,0	71,0	29,0	.	.	.	.	29,0	.	0,1	0,0	88,9
MEDIAN	100,0	71,0	29,0	.	.	.	.	29,0	.	0,1	0,1	88,9
NUMBER OF OBSERVATIONS	1	1	1	0	0	0	0	1	0	1	2	1

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

basin in the activated sludge process. It is a recently developed process that has been shown to upgrade effluent quality in conventional activated sludge plants. In the PAC treatment process the carbon concentration in the mixed liquor is generally equal to or greater than the volatile mixed liquor suspended solids level. The carbon and adsorbed substances are removed as part of the waste biological sludge.

Activated Carbon Adsorption - The use of activated carbon adsorption can be confined to the removal of specific compounds or classes of compounds from wastewater streams, or for the removal of such parameters as COD, BOD and color. Although more common as in-process treatment, it is also used for tertiary treatment.

An aspect of granular carbon carbon columns that is currently receiving attention is the role and possible benefits of biological growth on the carbon surfaces. In some applications much of the removal has been found to result from biodegredation rather than from adsorption.

Six plants in the Summary Data Base reported using activated carbon as their principal EOP treatment. The performance of these systems is summarized in Table 7-23.

Filtration - Filtration may be employed to polish an existing biological effluent, to prepare wastewater for a subsequent advanced treatment process, or to enable direct reuse of a discharge. Filtration of a secondary effluent will remove additional BOD and TSS, and reduce turbidity.

Reverse Osmosis/Ultrafiltration - Reverse osmosis is a physical separation process that relies on applied pressure at a level greater than osmotic pressure to force flow through a semi-permeable membrane. The process is capable of removing suspended particles and substantial fractions of dissolved impurities, including organic and inorganic materials. The process results in two effluents, one relatively pure and the other containing the concentrated substances. Reverse osmosis systems generally require extensive pretreatment (pH adjustment, filtration, chemical precipitation, activated carbon adsorption) of the wastewater stream to prevent rapid fouling or deterioration of the membrane surface.

Ultrafiltration is similar to reverse osmosis and relies on a semipermeable membrane and an applied driving force to separate suspended and dissolved materials from wastewater. The membranes used in ultrafiltration have pores large enough to eliminate osmotic pressure as a factor and to allow operation at pressures as low as five to ten psi. Sieving is the predominant mechanism of removal and the process is usually applicable for the removal of materials that have a molecular weight above 500 and that have very small osmotic pressures at a moderate concentration.

Combined Secondary and Tertiary Treatment System - In practice primary, secondary and tertiary processes are often used in series to treat OCPS industry wastewater. In fact, of the 146 plants employing biological treatment in the Summary Data Base, 58 use a form of treatment after

TABLE 7-23

ACTIVATED CARBON, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 7

	EFF FLOW MGD	BOD INF MG/L	BOD EFF MG/L	BOD % RED	TSS INF MG/L	TSS EFF MG/L	TSS % RED	COD INF MG/L	COD EFF MG/L	COD % RED	O&G INF MG/L	O&G EFF MG/L	O&G % RED
MAXIMUM	0.334	1743.0	772.0	55.7	847.0	37.0	97.5	4556.0	1326.0	78.0	.	1.5	.
MEAN	0.132	1273.0	206.2	54.9	433.0	23.0	51.4	2606.0	410.8	75.0	.	1.2	.
MINIMUM	0.014	803.0	8.0	54.2	19.0	16.0	5.3	286.0	68.0	70.9	.	1.0	.
MEDIAN	0.127	1273.0	38.0	54.9	433.0	19.5	51.4	2976.0	171.0	76.2	.	1.2	.
NUMBER OF OBSERVATIONS	6	2	6	2	2	4	2	3	6	3	0	2	0

ACTIVATED CARBON, ALL WASTE STREAMS

NUMBER OF STREAMS REPORTING THIS TECHNOLOGY AS MAJOR[a] WASTEWATER TREATMENT: 7

	TOC INF MG/L	TOC EFF MG/L	TOC % RED	PHENOL INF MG/L	PHENOL EFF MG/L	PHENOL % RED	NH3N INF MG/L	NH3N EFF MG/L	NH3N % RED	CR INF MG/L	CR EFF MG/L	CR % RED
MAXIMUM	1455.0	315.0	78.4	173.0	2.2	99.8	.	.	.	.	0.0	.
MEAN	773.5	111.0	78.4	127.0	1.0	99.0	.	.	.	.	0.0	.
MINIMUM	92.0	24.0	78.4	88.0	0.2	97.5	.	.	.	.	0.0	.
MEDIAN	773.5	52.5	78.4	120.0	0.6	99.7	.	.	.	.	0.0	.
NUMBER OF OBSERVATIONS	2	4	1	3	3	3	0	0	0	0	1	0

[a] These data are from plants that use this technology as the principal component of their wastewater treatment system.

secondary. The most prevalent tertiary process in the industry Summary Data Base is polishing ponds. A total of 34 plants reported using polishing ponds. Filtration and a combination of filtration and polishing ponds are the next most common tertiary processes in use with 11 streams utilizing this process.

Design, Operation and Management Practices

The need for good engineering design, good operating practices and conscientious waste management is as important in waste treatment as in chemical manufacturing. The design of the system must be site specific in that it must consider raw waste components, organic and hydraulic load variations, manufacturing practices, waste temperature, operator capabilities and other considerations which may be unique to the site. Operating practices must be based on a thorough understanding of mechanisms at work and probable response to changes in operating conditions. Waste management must be considered when planning for production campaigns, prodution shutdowns and new product addition, and should also include contingency planning for mechanical failures, inadvertent discharges and treatment system upsets.

As previously stated, optimum treatment system performance is usually obtained under so called "steady state conditions." This condition could be approached in wastewater from a single product, continuous process manufacturing operation. Such a situtation is unfortunately uncommon in OCPS plants. Many OCPS plants produce a variety of products, often on a campaign basis, using production operations which may be either continuous or batch. This frequently results in wastewater which varies significantly in composition and quantity.

Equalization and storage is the primary design approach taken to minimize this problem. It may be possible in some instances to modify production schedules to avoid simultaneous multiple batch discharges or cleanup operations to avoid excessive peak loads. Treatment plant operators should be advised of known or anticipated waste load changes so that they may respond accordingly, i.e., increase aeration, divert and hold accidental discharges, increase chemical feed rates, etc.

Plants operating in cold weather conditions should recognize that unnecessarily excessive storage prior to treatment may reduce the temperature of the biotreatment system. Cold temperature operation may require insulation of treatment units, covering of open tanks, and tracing of chemical feed lines. Insulation of treatment units may include installing tanks inground rather than above ground, using soil around the walls of above-ground units to prevent heat loss, or providing enclosures around treatment units. Operators should recognize that during colder periods it may be necessary to maintain higher MLSS concentrations, which may in turn require greater operator attention to effluent solids concentrations.

Plants operating in hot weather climates may be required to reduce waste temperatures to maintain a suitable treatment environment. Natural or mechanically induced evaporation may be used to reduce waste temperatures.

Control of toxic and inhibitory waste components may be required to avoid treatment system upsets. This may be accomplished by separation and segregation of the material at the point of waste generation, or destruction or removal of the material through the use of a pretreatment system. Waste components typically handled in this manner include cyanides, heavy metals and metallic sulfides. In the case of inhibitory components, equalization and subsequent dilution may be sufficient to eliminate the inhibition.

Upgrading Biological Treatment Systems

Many treatment systems in the OCPS industry have undergone one or more major modifications to upgrade performance since the initial installation of the system. The four most common reasons for plant upgrading are:

1. To accommodate changing environmental regulations
2. To accommodate higher loads from expanded production facilities
3. To accommodate wasteloads associated with the manufacture of new products
4. To address inadequacies in the treatment system design

Because of the modular nature of most treatment systems, upgrading is most commonly accomplished by adding additional modules. When the upgrading is done to increase treatment system capacity, it is commonly done by adding modules similar to those already installed, i.e., additional aeration basins or clarifiers. Upgrading to accommodate more stringent treatment requirements usually involves adding new treatment process unit operations to an existing treatment train, e.g., addition of multi-media filtration following secondary clarification or addition of a coagulant feed system to a primary clarifier.

The nature of this evaluation of treatment system capability is best illustrated by use of an example. Consider a hypothetical chemical plant whose treatment system initially consists of a simple aerobic lagoon. The first level of upgrading could include providing aeration to convert the aerobic lagoon to an aerated lagoon. The next level of upgrading might include the addition of secondary clarification to return solids, thus converting the lagoon to an activated sludge system, providing some initial equalization capacity, and providing an aerobic digestor to stabilize waste secondary solids. The next level of upgrading could include the installation of a dissolved air flotation system to reduce influent suspended solids or oils, addition of multi-media filtration to reduce effluent solids, and the addition of solids dewatering equipment to allow for landfill disposal of waste activated sludge.

The OCPS industry provides several examples of similar upgrades:

Plant 53 - This plant was upgraded in June 1977. Facilities originally consisted of an equalization basin and aerated lagoon. The lagoon was converted to activated sludge by the addition of two clarifiers and additional aeration basin capacity. Solids handling equipment and an aerobic solids disgestor were also added. Change in operating performance was as follows:

	Before Upgrade	After Upgrade
Effluent BOD	316 mg/l	28 mg/l
Effluent TSS	63 mg/l	74 mg/l

Plant 292 - This plant was upgraded in late 1977. The existing activated sludge system was upgraded by adding multi-media filters followed by granular activated carbon contactors. Other changes included an improved solids handling system comprised of gravity thickening, vacuum filtration and multiple hearth incineration.

	Before Upgrade	After Upgrade
Effluent BOD	20 mg/l	12 mg/l
Effluent TSS	56 mg/l	34 mg/l

This plant, and plant 53, are somewhat unusual in that they exhibit negative TSS removals. This will occur in any biological system where the loss of biological solids from the secondary solids separation system to the effluent is greater than the influent TSS received by the biological system. When a treatment system is achieving good secondary solids capture, typically 50 mg/l or less effluent TSS, the occurrence of a negative TSS removal percentage is not significant.

Plant 60 - This plant was upgraded in 1977. Treatment originally consisted of equalization, neutralization, primary clarification, aerated lagoon and final clarification. The system was converted to completely mixed activated sludge. Aerobic digestion, gravity thickening, pressure filtration and an onsite landfill were also provided. Change in operating performance was as follows:

	Before Upgrade	After Upgrade
Effluent BOD	510 mg/l	41 mg/l
Effluent TSS	No Data	No Data

Plant 45 - This plant originally had an activated sludge system with primary clarification. The plant was upgraded by the addition of a 3.5 million gallon equalization basin and mixed-media filtration. Additional aeration capacity was installed and a second secondary clarifier was added. New sludge handling facilities consisting of two pressure filters were installed to accommodate increased solids production.

	Before Upgrade	After Upgrade
Effluent BOD	46 mg/l	3 mg/l
Effluent TSS	91 mg/l	24 mg/l

Plant 109 - In 1976 this activated sludge system was upgraded through the addition of an extended aeration basin and multi-media filtration. Both units were added downstream of the existing treatment plant. In 1977, additional blower (aeration) capacity was added.

	Before Upgrade	After Upgrade
Effluent BOD	12 mg/l	3 mg/l
Effluent TSS	83 mg/l	No Data

Plant 118 - This plant was originally operated as a single stage trickling filter plant. In 1977 it was ugraded by the addition of a dissolved air flotation system to accomplish primary treatment, and added a UNOX pure oxygen system as a second stage biological treatment unit.

	Before Upgrade	After Upgrade
Effluent BOD	293 mg/l	13 mg/l
Effluent TSS	No Data	No Data

Plant 269 - This treatment facility originally consisted of clarification, neutralization and activated sludge. In late 1977 it was upgraded by the addition of increased primary sedimentation capacity, the addition of an equalization basin prior to the activated sludge system, additional instrumentation, the addition of another secondary clarifier and improvements to the sludge handling facilities.

	Before Upgrade	After Upgrade
Effluent BOD	255 mg/l	66 mg/l
Effluent TSS	No Data	No Data

Plant 281 - The original activated sludge system at this plant was upgraded in 1977. System improvements included the addition of an emergency holding basin and a stormwater holding basin, the addition of equalization upstream of existing treatment units, chromium reduction on a boiler blowdown stream and some in-plant flow reductions. An additional secondary clarifier was also added.

	Before Upgrade	After Upgrade
Effluent BOD	15 mg/l	11 mg/l
Effluent TSS	46 mg/l	No Data

OCPS EFFLUENT QUALITY

Effluent quality in the OCPS industry, as defined by conventional pollutant parameters, is determined by several factors. Those factors with the greatest influence on effluent quality include: the origin of the wastewater, the type of treatment system used, and the design and operation of the treatment system.

The origin of the wastewater, which takes into account the type of products manufactured and manufacturing processes used, has already been discussed in Section IV. In that section a subcategorization scheme based on wastewater origin was developed.

In determining the effluent quality achievable by OCPS plants, biological treatment has been evaluated as the principal treatment practice within the industry. Of the 185 plants for which treatment system information is available, 146 use some form of biological treatment. Although nonbiological treatment systems are often used to produce high quality effluents, only biological treatment has been sufficiently applied to be considered as applicable across the broad spectrum of the OCPS industry.

The various biological treatment technologies differ only in the mechanical means by which the wastewater, biomass and essential nutrients are brought together. Although an activated sludge system and rotating biological contactor appear very different, the biological processes are similar. Therefore, it follows that all biological systems, including air and pure oxygen activated sludge, trickling filters, aerobic and aerated lagoons, and rotating biological contactors should, given sufficient detention time, achieve essentially the same effluent BOD_5 concentration. This is illustrated by Table 7-24 which presents summary performance data by subcategory for all biological systems, activated sludge systems and all biological systems other than activated sludge.

Although some variations are apparent, particularly where the data base in a given subcategory is limited, the data generally tend to support the above statement. On this basis, biological treatment in general may be considered the best technology for treatment of OCPS wastewaters. The specific mechanical system used to accomplish biological treatment will depend on cost, available space, climate and other site-specific considerations.

TABLE 7-24

BIOLOGICAL SYSTEMS
BOD5 EFFLUENT CONCENTRATIONS

BOD5 EFFLUENT CONCENTRATION	PLASTICS ONLY	NOT PLASTICS TYPE I AND C *	NOT PLASTICS TYPE I NOT C **	NOT PLASTICS NOT TYPE I	ALL WASTE STREAMS
	MINIMUM= 3.0	MINIMUM= 6.0	MINIMUM= 9.0	MINIMUM= 3.0	MINIMUM= 3.0
	MAXIMUM= 86.0	MAXIMUM= 468.0	MAXIMUM= 780.0	MAXIMUM= 279.0	MAXIMUM= 780.0
	MEAN = 19.9	MEAN = 81.5	MEAN = 80.4	MEAN = 34.7	MEAN = 52.8
	MEDIAN = 14.0	MEDIAN = 41.0	MEDIAN = 28.0	MEDIAN = 17.0	MEDIAN = 23.0
	N = 53	N = 50	N = 21	N = 15	N = 139

ACTIVATED SLUDGE ONLY
BOD5 EFFLUENT CONCENTRATIONS

BOD5 EFFLUENT CONCENTRATION	PLASTICS ONLY	NOT PLASTICS TYPE I AND C *	NOT PLASTICS TYPE I NOT C **	NOT PLASTICS NOT TYPE I	ALL WASTE STREAMS
	MINIMUM= 3.0	MINIMUM= 6.0	MINIMUM= 11.0	MINIMUM= 3.0	MINIMUM= 3.0
	MAXIMUM= 58.0	MAXIMUM= 468.0	MAXIMUM= 750.0	MAXIMUM= 27.0	MAXIMUM= 780.0
	MEAN = 17.8	MEAN = 86.0	MEAN = 112.2	MEAN = 15.6	MEAN = 57.4
	MEDIAN = 10.5	MEDIAN = 50.0	MEDIAN = 28.0	MEDIAN = 14.0	MEDIAN = 26.0
	N = 38	N = 41	N = 13	N = 9	N = 101

BIOLOGICAL SYSTEMS, NOT ACTIVATED SLUDGE
BOD5 EFFLUENT CONCENTRATIONS

BOD5 EFFLUENT CONCENTRATION	PLASTICS ONLY	NOT PLASTICS TYPE I AND C *	NOT PLASTICS TYPE I NOT C **	NOT PLASTICS NOT TYPE I	ALL WASTE STREAMS
	MINIMUM= 4.0	MINIMUM= 7.0	MINIMUM= 9.0	MINIMUM= 8.0	MINIMUM= 4.0
	MAXIMUM= 86.0	MAXIMUM= 251.0	MAXIMUM= 80.0	MAXIMUM= 279.0	MAXIMUM= 279.0
	MEAN = 25.3	MEAN = 60.8	MEAN = 28.8	MEAN = 63.5	MEAN = 40.5
	MEDIAN = 20.0	MEDIAN = 22.0	MEDIAN = 19.5	MEDIAN = 20.0	MEDIAN = 20.5
	N = 15	N = 9	N = 8	N = 6	N = 38

* Type I w/Oxidation
** Type I w/o Oxidation

The 146 plants in the Summary Data Base which use some form of biological treatment, treat a total of 176 different waste streams. Single stage biological systems are used to treat 138 waste streams. The remaining 38 waste streams are treated using two separate biological units in series. Table 7-25 compares the performance of single and two stage biological systems. It is apparent that plants using two stage biological treatment do not achieve lower effluent concentrations than single stage systems. In several subcategories, single stage systems produced lower effluent BOD_5 concentrations than two stage systems. This apparent contradiction may have resulted from the fact that the second stage of many two stage systems was added to upgrade a single stage system which was either poorly designed, poorly operated or overloaded follow ing installation. However, due to the absence of interstage monitoring data, this assumption cannot be verified.

Use of biological treatment as the principal treatment practice will produce high quality effluents as shown in the previous tables. An evaluation was done to determine if additional treatment processes, i.e., polishing ponds and filtration, would further improve effluent quality. Tables 7-26 and 7-27 present summary data by subcategory which illustrate effluent BOD_5 concentrations from plants using biological treatment with polishing ponds and filtration processes. A comparison of the median concentrations in each category indicates that plants with additional processes do not achieve significantly different effluent BOD concentrations than plants with only biological treatment.

Although biological treatment has been demonstrated to achieve low effluent BOD_5 concentrations, the median value obtained for all biological systems in the industry is not considered to represent the best level of treatment which could be achieved. While some plants in the data base are well designed and operated, others are operating at less than optimum performance. In order to segregate good performers from bad performers, it was necessary to develop a statistical test to distinguish the better plants from those operating less efficiently.

Table 7-28 presents a summary of the BOD percent removals for biological systems in the Summary Data Base. The median for all systems (108 streams) is 95.2% BOD removal. The medians for all subcatgories are also approximately 95%. Table 7-29 presents effluent data for those plants achieving 95% removal. These show significantly better effluents than for all biological systems shown in Table 7-23. Based on this analysis, 95% BOD removal has been determined to represent well operated systems.

It is also recognized that use of the 95% removal criteria eliminates some plants which achieve lower effluent BOD_5 concentrations, but by virtue of having very low influent BOD_5 concentrations, do not achieve 95% removal. In addition, there are well operated plants that have not reported percent removal data. In an attempt to address this potential inconsistency, a new segment was evaluated which included all plants which achieved 95% BOD_5 reduction or which achieved an effluent BOD_5 concentration of 50 mg/l or less. The resulting frequency distribution of plants as a function of effluent BOD_5 concentration and the summary statistics are presented in Table 7-30. A second analysis was

TABLE 7-25

SINGLE STAGE BIOLOGICAL SYSTEMS ONLY
BOD5 EFFLUENT CONCENTRATIONS

BOD5 EFFLUENT CONCENTRATION	PLASTICS ONLY	NOT PLASTICS TYPE I AND C *	NOT PLASTICS TYPE I NOT C **	NOT PLASTICS NOT TYPE I	ALL WASTE STREAMS
	MINIMUM= 3,0	MINIMUM= 6,0	MINIMUM= 9,0	MINIMUM= 3,0	MINIMUM= 3,0
	MAXIMUM= 86,0	MAXIMUM= 468,0	MAXIMUM= 780,0	MAXIMUM= 279,0	MAXIMUM= 780,0
	MEAN = 19,9	MEAN = 78,1	MEAN = 80,4	MEAN = 34,7	MEAN = 51,4
	MEDIAN = 14,0	MEDIAN = 41,0	MEDIAN = 28,0	MEDIAN = 17,0	MEDIAN = 23,0
	N = 53	N = 49	N = 21	N = 15	N = 138

TWO STAGE BIOLOGICAL SYSTEMS ONLY
BOD5 EFFLUENT CONCENTRATIONS

BOD5 EFFLUENT CONCENTRATION	PLASTICS ONLY	NOT PLASTICS TYPE I AND C *	NOT PLASTICS TYPE I NOT C **	NOT PLASTICS NOT TYPE I	ALL WASTE STREAMS
	MINIMUM= 9.0	MINIMUM= 7.0	MINIMUM= 13.0	MINIMUM= 3.0	MINIMUM= 3.0
	MAXIMUM= 45.0	MAXIMUM= 468.0	MAXIMUM= 181.0	MAXIMUM= 42.0	MAXIMUM= 468.0
	MEAN = 21.8	MEAN = 106.7	MEAN = 87.7	MEAN = 22.3	MEAN = 70.2
	MEDIAN = 17.0	MEDIAN = 41.0	MEDIAN = 63.5	MEDIAN = 22.0	MEDIAN = 33.0
	N = 12	N = 17	N = 6	N = 3	N = 38

* Type I w/Oxidation
** Type I w/o Oxidation

TABLE 7-26

BIOLOGICAL SYSTEMS WITH POLISHING
BOD5 EFFLUENT CONCENTRATIONS

BOD5 EFFLUENT CONCENTRATION (<=MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C*		NOT PLASTICS TYPE I NOT C **		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	9	64.3	5	33.3	0	0.0	3	42.9	17	43.6
30	10	71.4	6	40.0	0	0.0	6	85.7	22	56.4
40	13	92.9	7	46.7	1	33.3	6	85.7	27	69.2
50	14	100.0	8	53.3	2	66.7	7	100.0	31	79.5
100	14	100.0	13	86.7	2	66.7	7	100.0	36	92.3
200	14	100.0	15	100.0	3	100.0	7	100.0	39	100.0
300	14	100.0	15	100.0	3	100.0	7	100.0	39	100.0
400	14	100.0	15	100.0	3	100.0	7	100.0	39	100.0
500	14	100.0	15	100.0	3	100.0	7	100.0	39	100.0
600	14	100.0	15	100.0	3	100.0	7	100.0	39	100.0
700	14	100.0	15	100.0	3	100.0	7	100.0	39	100.0
800	14	100.0	15	100.0	3	100.0	7	100.0	39	100.0

SUMMARY STATISTICS

	MINIMUM= 6.0	MINIMUM= 10.0	MINIMUM= 37.0	MINIMUM= 3.0	MINIMUM= 3.0
	MAXIMUM= 45.0	MAXIMUM= 104.0	MAXIMUM= 168.0	MAXIMUM= 42.0	MAXIMUM= 168.0
	MEAN = 18.9	MEAN = 48.5	MEAN = 84.0	MEAN = 19.1	MEAN = 35.3
	MEDIAN = 10.0	MEDIAN = 50.0	MEDIAN = 47.0	MEDIAN = 22.0	MEDIAN = 23.0
	N = 14	N = 15	N = 3	N = 7	N = 39

* Type I w/Oxidation
** Type I w/o/Oxidation

TABLE 7-27

BIOLOGICAL SYSTEMS WITH MMF
BOD5 EFFLUENT CONCENTRATIONS

BOD5 EFFLUENT CONCENTRATION (<=MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C*		NOT PLASTICS TYPE I NOT C**		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	2	66.7	2	50.0	0	0.0	1	100.0	5	50.0
30	2	66.7	2	50.0	1	50.0	1	100.0	6	60.0
40	3	100.0	2	50.0	1	50.0	1	100.0	7	70.0
50	3	100.0	2	50.0	1	50.0	1	100.0	7	70.0
100	3	100.0	3	75.0	2	100.0	1	100.0	9	90.0
200	3	100.0	4	100.0	2	100.0	1	100.0	10	100.0
300	3	100.0	4	100.0	2	100.0	1	100.0	10	100.0
400	3	100.0	4	100.0	2	100.0	1	100.0	10	100.0
500	3	100.0	4	100.0	2	100.0	1	100.0	10	100.0
600	3	100.0	4	100.0	2	100.0	1	100.0	10	100.0
700	3	100.0	4	100.0	2	100.0	1	100.0	10	100.0
800	3	100.0	4	100.0	2	100.0	1	100.0	10	100.0

SUMMARY STATISTICS

	MINIMUM=	3.0	MINIMUM=	12.0	MINIMUM=	26.0	MINIMUM=	17.0	MINIMUM=	3.0
	MAXIMUM=	37.0	MAXIMUM=	103.0	MAXIMUM=	80.0	MAXIMUM=	17.0	MAXIMUM=	103.0
	MEAN =	15.3	MEAN =	51.5	MEAN =	53.0	MEAN =	17.0	MEAN =	37.5
	MEDIAN =	6.0	MEDIAN =	45.5	MEDIAN =	53.0	MEDIAN =	17.0	MEDIAN =	22.5
	N =	3	N =	4	N =	2	N =	1	N =	10

* Type I w/Oxidation
** Type I w/o/Oxidation

TABLE 7-28

BIOLOGICAL SYSTEMS
BOD5 % REMOVAL

BOD5 EFFLUENT CONCENTRATION (MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C*		NOT PLASTICS TYPE I NOT C **		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
40	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
50	1	2.3	1	2.6	0	0.0	0	0.0	2	1.9
60	1	2.3	1	2.6	0	0.0	0	0.0	2	1.9
70	1	2.3	2	5.1	0	0.0	0	0.0	3	2.8
80	3	7.0	3	7.7	1	5.9	0	0.0	7	6.5
90	8	18.6	6	15.4	7	41.2	1	11.1	22	20.4
92	10	23.3	10	25.6	8	47.1	3	33.3	31	28.7
94	19	44.2	13	33.3	11	64.7	3	33.3	46	42.6
96	25	58.1	20	51.3	12	70.6	6	66.7	63	58.3
98	36	63.7	27	69.2	16	94.1	9	100.0	68	81.5
100	43	100.0	39	100.0	17	100.0	9	100.0	108	100.0

SUMMARY STATISTICS

	MINIMUM=	41.0	MINIMUM=	47.5	MINIMUM=	70.8	MINIMUM=	86.1	MINIMUM=	41.0
	MAXIMUM=	99.7	MAXIMUM=	99.6	MAXIMUM=	96.0	MAXIMUM=	97.0	MAXIMUM=	99.7
	MEAN =	92.5	MEAN =	92.7	MEAN =	91.0	MEAN =	94.2	MEAN =	92.5
	MEDIAN =	94.7	MEDIAN =	95.7	MEDIAN =	92.0	MEDIAN =	95.4	MEDIAN =	95.2
	N =	43	N =	39	N =	17	N =	9	N =	108

* Type I w/Oxidation
** Type I w/o/Oxidation

TABLE 7-29

BIOLOGICAL SYSTEMS
BOD5 EFFLUENT CONCENTRATIONS
% REMOVAL >= 95%

BOD5 EFFLUENT CONCENTRATION (<=MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C *		NOT PLASTICS TYPE I NOT C**		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	15	75.0	6	26.1	2	33.3	4	66.7	27	49.1
30	16	80.0	11	47.8	4	66.7	6	100.0	37	67.3
40	17	85.0	16	69.6	4	66.7	6	100.0	43	78.2
50	19	95.0	17	73.9	5	83.3	6	100.0	47	85.5
100	20	100.0	21	91.3	6	100.0	6	100.0	53	96.4
200	20	100.0	23	100.0	6	100.0	6	100.0	55	100.0
300	20	100.0	23	100.0	6	100.0	6	100.0	55	100.0
400	20	100.0	23	100.0	6	100.0	6	100.0	55	100.0
500	20	100.0	23	100.0	6	100.0	6	100.0	55	100.0
600	20	100.0	23	100.0	6	100.0	6	100.0	55	100.0
700	20	100.0	23	100.0	6	100.0	6	100.0	55	100.0
800	20	100.0	23	100.0	6	100.0	6	100.0	55	100.0

SUMMARY STATISTICS

	MINIMUM= 3.0	MINIMUM= 6.0	MINIMUM= 13.0	MINIMUM= 5.0	MINIMUM= 3.0
	MAXIMUM= 52.0	MAXIMUM= 154.0	MAXIMUM= 82.0	MAXIMUM= 24.0	MAXIMUM= 154.0
	MEAN = 16.8	MEAN = 43.3	MEAN = 34.3	MEAN = 14.0	MEAN = 29.5
	MEDIAN = 9.5	MEDIAN = 33.0	MEDIAN = 25.5	MEDIAN = 12.0	MEDIAN = 21.0
	N = 20	N = 23	N = 6	N = 6	N = 55

* Type I w/oxidation
** Type I w/o/oxidation

TABLE 7-30

BIOLOGICAL SYSTEMS
BOD5 EFFLUENT CONCENTRATIONS
% REMOVAL >= 95% OR EFFLUENT BOD <= 50 MG/L

BOD5 EFFLUENT CONCENTRATION (<=MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C*		NOT PLASTICS TYPE I NOT C**		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	35	68.6	12	36.4	7	43.8	8	57.1	62	54.4
30	40	78.4	17	51.5	12	75.0	13	92.9	82	71.9
40	46	90.2	24	72.7	14	87.5	13	92.9	97	85.1
50	50	98.0	27	81.8	15	93.8	14	100.0	106	93.0
100	51	100.0	31	93.9	16	100.0	14	100.0	112	98.2
200	51	100.0	33	100.0	16	100.0	14	100.0	114	100.0
300	51	100.0	33	100.0	16	100.0	14	100.0	114	100.0
400	51	100.0	33	100.0	16	100.0	14	100.0	114	100.0
500	51	100.0	33	100.0	16	100.0	14	100.0	114	100.0
600	51	100.0	33	100.0	16	100.0	14	100.0	114	100.0
700	51	100.0	33	100.0	16	100.0	14	100.0	114	100.0
800	51	100.0	33	100.0	16	100.0	14	100.0	114	100.0

SUMMARY STATISTICS

	MINIMUM=	3.0	MINIMUM=	6.0	MINIMUM=	9.0	MINIMUM=	3.0	MINIMUM=	3.0
	MAXIMUM=	52.0	MAXIMUM=	154.0	MAXIMUM=	82.0	MAXIMUM=	42.0	MAXIMUM=	154.0
	MEAN =	17.9	MEAN =	37.2	MEAN =	25.9	MEAN =	17.3	MEAN =	24.5
	MEDIAN =	12.0	MEDIAN =	30.0	MEDIAN =	24.5	MEDIAN =	15.5	MEDIAN =	18.0
	N =	51	N =	33	N =	16	N =	14	N =	114

* Type I w/oxidation
** Type I w/o/oxidation

made using the criteria of plants which achieve 95% BOD reduction or which have an effluent BOD_5 concentration of 30 mg/l or less. The results of this analysis are presented in Table 7-31.

In reviewing the data, it appeared that well operated Type I and C plants exhibited a wider range of effluent BOD values than the plants in the other subcategories. Subsequent investigations showed that this effect appeared to be related to the efficiency of water use by plants in the Type I and C subcategory. Water use efficiency was defined as a plant's daily water usage divided by its daily production level. The resulting water use, in gallons per pound of production, was plotted as a function of effluent BOD_5 concentration for the plants in the subcategory identified as achieving 95% removal or effluent BOD less than 50 mg/l. This plot is presented as Figure 7-4. The figure indicates that plants with low water use, i.e., less than 0.2 gallons per pound, generally do not achieve effluent BOD_5 concentrations as low as do plants with higher water usage. A more detailed analysis showed this effect to be limited to those plants in the first quartile of water use. This included plants with water use equal to 0.165 gallons per pound or less. This would suggest that the Not Plastics, Type I and C subcategory be further divided into low flow (less than or equal to 0.165 gallons per pound) and high flow (greater than 0.165 gallons per pound) subcategories. If this is accomplished, the resulting median effluent BOD_5 concentrations of plants with greater than 95% removal or 50 mg/l effluent BOD_5 would be 26 mg/l for high flow and 36 mg/l for low flow plants.

It was previously shown that biological plants followed by additional unit processes do not achieve significantly lower effluent BOD_5 concentrations than biological systems alone. This is not the case for effluent TSS concentrations. Table 7-32 through 7-35 present a comparison of summary statistics for effluent TSS concentrations based on biological systems meeting the 95/50 criteria, and 95/50 biological systems followed by additional unit processes such as polishing ponds, multimedia filters and activated carbon. These tables show that systems which include polishing ponds or filters achieve lower median effluent TSS concentrations than those systems which do not. In addition, these data indicate that polishing ponds and filters achieve comparable effluent TSS levels.

EFFLUENT VARIABILITY

It is well known that biological wastewater treatment systems produce an effluent of varying quality, much of this attributable to the inherent nature of the treatment process. The range of this variation is dependent on many process characteristics. In some cases significant changes in effluent quality may be associated with specific causes such as shock loads, mechanical failures, poor design or operation, or errors in sampling or analysis.

The term variability, as used in this context, is defined as the variation in the effluent quality from a properly designed and operated biological treatment system which is attributable to the basic nature of the treatment process. Minimizing the impact of the cited specific causes of variability through the use of proper design and management techniques can reduce to a minimum the effluent variability which the

TABLE 7-31

BIOLOGICAL SYSTEMS
BOD5 EFFLUENT CONCENTRATIONS
% REMOVAL >= 95% OR EFFLUENT BOD <= 30 MG/L

BOD5 EFFLUENT CONCENTRATION (<=MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C*		NOT PLASTICS TYPE I NOT C**		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	35	79.5	12	41.4	7	50.0	8	61.5	62	62.0
30	40	90.9	17	58.6	12	85.7	13	100.0	82	82.0
40	41	93.2	22	75.9	12	85.7	13	100.0	88	88.0
50	43	97.7	23	79.3	13	92.9	13	100.0	92	92.0
100	44	100.0	27	93.1	14	100.0	13	100.0	98	98.0
200	44	100.0	29	100.0	14	100.0	13	100.0	100	100.0
300	44	100.0	29	100.0	14	100.0	13	100.0	100	100.0
400	44	100.0	29	100.0	14	100.0	13	100.0	100	100.0
500	44	100.0	29	100.0	14	100.0	13	100.0	100	100.0
600	44	100.0	29	100.0	14	100.0	13	100.0	100	100.0
700	44	100.0	29	100.0	14	100.0	13	100.0	100	100.0
800	44	100.0	29	100.0	14	100.0	13	100.0	100	100.0

SUMMARY STATISTICS

	MINIMUM=	3.0	MINIMUM=	6.0	MINIMUM=	5.0	MINIMUM=	3.0	MINIMUM=	3.0
	MAXIMUM=	52.0	MAXIMUM=	154.0	MAXIMUM=	62.0	MAXIMUM=	27.0	MAXIMUM=	154.0
	MEAN =	14.7	MEAN =	36.7	MEAN =	24.7	MEAN =	15.4	MEAN =	22.6
	MEDIAN =	10.0	MEDIAN =	24.0	MEDIAN =	20.0	MEDIAN =	14.0	MEDIAN =	15.0
	N =	44	N =	29	N =	14	N =	13	N =	100

* Type I w/oxidation
** Type I w/o/oxidation

FIGURE 7-4

TYPE I & C PLANTS WITH BIOLOGICAL TREATMENT
EFFLUENT BOD VS. GAL/LB PRODUCT WATER DISCHARGED

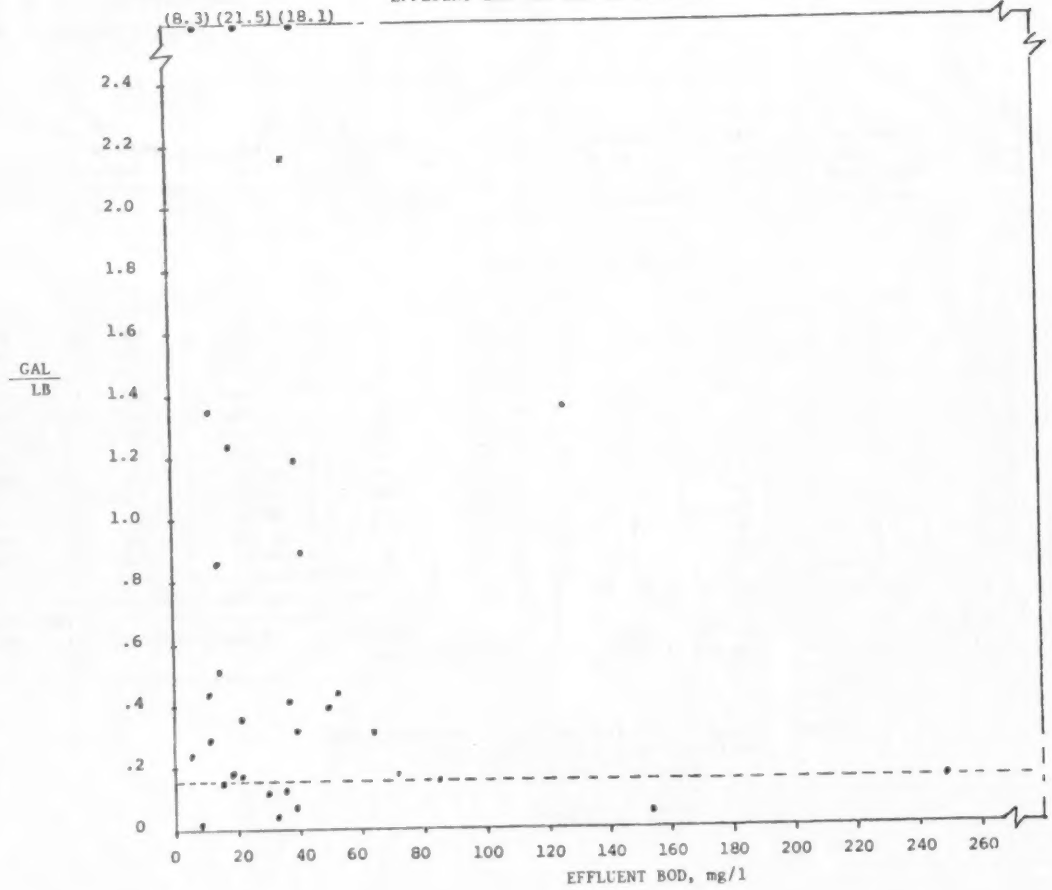


TABLE 7-32

BIOLOGICAL SYSTEMS
TSS EFFLUENT CONCENTRATIONS
BOD %REMOVAL >=95% OR EFFLUENT BOD <=50MG/L

TSS EFFLUENT CONCENTRATION (<=MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C		NOT PLASTICS TYPE I NOT C		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	19	39.6	3	10.7	4	33.3	4	28.6	30	29.4
30	29	60.4	6	21.4	5	41.7	7	50.0	47	46.1
40	34	70.8	10	35.7	7	58.3	10	71.4	61	59.8
50	36	75.0	12	42.9	9	75.0	11	78.6	68	66.7
100	46	95.8	21	75.0	11	91.7	13	92.9	91	89.2
200	48	100.0	28	100.0	12	100.0	14	100.0	102	100.0
300	48	100.0	28	100.0	12	100.0	14	100.0	102	100.0
400	48	100.0	28	100.0	12	100.0	14	100.0	102	100.0
500	48	100.0	28	100.0	12	100.0	14	100.0	102	100.0
600	48	100.0	28	100.0	12	100.0	14	100.0	102	100.0
700	48	100.0	28	100.0	12	100.0	14	100.0	102	100.0
800	48	100.0	28	100.0	12	100.0	14	100.0	102	100.0

SUMMARY STATISTICS

	MINIMUM=	4.0	MINIMUM=	9.0	MINIMUM=	13.0	MINIMUM=	2.0	MINIMUM=	2.0
	MAXIMUM=	127.0	MAXIMUM=	189.0	MAXIMUM=	106.0	MAXIMUM=	101.0	MAXIMUM=	189.0
	MEAN =	36.1	MEAN =	71.3	MEAN =	40.8	MEAN =	36.4	MEAN =	46.3
	MEDIAN =	24.5	MEDIAN =	63.5	MEDIAN =	34.5	MEDIAN =	30.5	MEDIAN =	33.0
	N =	48	N =	28	N =	12	N =	14	N =	102

* Type I w/Oxidation
** Type I w/o/Oxidation

TABLE 7-33

BIOLOGICAL SYSTEMS WITH POLISHING
TSS EFFLUENT CONCENTRATIONS
BOD %REMOVAL >=95% OR EFFLUENT BOD <=50MG/L

TSS EFFLUENT CONCENTRATION	PLASTICS ONLY		NOT PLASTICS TYPE I AND C		NOT PLASTICS TYPE I NOT C		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
(<=MG/L)	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	5	38.5	2	25.0	0	0.0	2	28.6	9	30.0
30	10	76.9	3	37.5	0	0.0	4	57.1	17	56.7
40	11	84.6	4	50.0	1	50.0	6	85.7	22	73.3
50	12	92.3	5	62.5	1	50.0	6	85.7	24	80.0
100	13	100.0	8	100.0	2	100.0	7	100.0	30	100.0
200	13	100.0	8	100.0	2	100.0	7	100.0	30	100.0
300	13	100.0	8	100.0	2	100.0	7	100.0	30	100.0
400	13	100.0	8	100.0	2	100.0	7	100.0	30	100.0
500	13	100.0	8	100.0	2	100.0	7	100.0	30	100.0
600	13	100.0	8	100.0	2	100.0	7	100.0	30	100.0
700	13	100.0	8	100.0	2	100.0	7	100.0	30	100.0
800	13	100.0	8	100.0	2	100.0	7	100.0	30	100.0

SUMMARY STATISTICS

	MINIMUM=	9.0	MINIMUM=	9.0	MINIMUM=	31.0	MINIMUM=	2.0	MINIMUM=	2.0
	MAXIMUM=	76.0	MAXIMUM=	95.0	MAXIMUM=	62.0	MAXIMUM=	55.0	MAXIMUM=	95.0
	MEAN =	26.3	MEAN =	49.5	MEAN =	46.5	MEAN =	27.7	MEAN =	34.2
	MEDIAN =	23.0	MEDIAN =	42.0	MEDIAN =	46.5	MEDIAN =	26.0	MEDIAN =	28.5
	N =	13	N =	8	N =	2	N =	7	N =	30

* Type I w/Oxidation
** Type I w/o/Oxidation

TABLE 7-34

BIOLOGICAL SYSTEMS WITH MMF
TSS EFFLUENT CONCENTRATIONS
BOD %REMOVAL >=95% OR EFFLUENT BOD <=50MG/L

TSS EFFLUENT CONCENTRATION (<=MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C		NOT PLASTICS TYPE I NOT C		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	1	33.3	1	33.3	0	0.0	1	100.0	3	37.5
30	3	100.0	2	66.7	0	0.0	1	100.0	6	75.0
40	3	100.0	2	66.7	0	0.0	1	100.0	6	75.0
50	3	100.0	2	66.7	1	100.0	1	100.0	7	87.5
100	3	100.0	3	100.0	1	100.0	1	100.0	8	100.0
200	3	100.0	3	100.0	1	100.0	1	100.0	8	100.0
300	3	100.0	3	100.0	1	100.0	1	100.0	8	100.0
400	3	100.0	3	100.0	1	100.0	1	100.0	8	100.0
500	3	100.0	3	100.0	1	100.0	1	100.0	8	100.0
600	3	100.0	3	100.0	1	100.0	1	100.0	8	100.0
700	3	100.0	3	100.0	1	100.0	1	100.0	8	100.0
800	3	100.0	3	100.0	1	100.0	1	100.0	8	100.0

SUMMARY STATISTICS

	MINIMUM=	18.0	MINIMUM=	19.0	MINIMUM=	48.0	MINIMUM=	12.0	MINIMUM=	12.0
	MAXIMUM=	24.0	MAXIMUM=	74.0	MAXIMUM=	48.0	MAXIMUM=	12.0	MAXIMUM=	74.0
	MEAN =	21.3	MEAN =	40.7	MEAN =	48.0	MEAN =	12.0	MEAN =	30.8
	MEDIAN =	22.0	MEDIAN =	29.0	MEDIAN =	48.0	MEDIAN =	12.0	MEDIAN =	23.0
	N =	3	N =	3	N =	1	N =	1	N =	8

* Type I w/Oxidation
** Type I w/o/Oxidation

TABLE 7-35

BIOLOGICAL SYSTEMS WITH ACTIVATED CARBON
TSS EFFLUENT CONCENTRATIONS
BOD %REMOVAL >=75% OR EFFLUENT BOD <=50MG/L

TSS EFFLUENT CONCENTRATION (<=MG/L)	PLASTICS ONLY		NOT PLASTICS TYPE I AND C*		NOT PLASTICS TYPE I NOT C **		NOT PLASTICS NOT TYPE I		ALL WASTE STREAMS	
	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %	CUM FREQ	CUM %
20	0	0.0	0	.	0	0.0	0	.	0	0.0
30	0	0.0	0	.	0	0.0	0	.	0	0.0
40	0	0.0	0	.	0	0.0	0	.	0	0.0
50	0	0.0	0	.	1	100.0	0	.	1	50.0
100	1	100.0	0	.	1	100.0	0	.	2	100.0
200	1	100.0	0	.	1	100.0	0	.	2	100.0
300	1	100.0	0	.	1	100.0	0	.	2	100.0
400	1	100.0	0	.	1	100.0	0	.	2	100.0
500	1	100.0	0	.	1	100.0	0	.	2	100.0
600	1	100.0	0	.	1	100.0	0	.	2	100.0
700	1	100.0	0	.	1	100.0	0	.	2	100.0
800	1	100.0	0	.	1	100.0	0	.	2	100.0

SUMMARY STATISTICS

MINIMUM=	76.0	MINIMUM=	.	MINIMUM=	48.0	MINIMUM=	.	MINIMUM=	48.0
MAXIMUM=	76.0	MAXIMUM=	.	MAXIMUM=	48.0	MAXIMUM=	.	MAXIMUM=	76.0
MEAN =	76.0	MEAN =	.	MEAN =	48.0	MEAN =	.	MEAN =	62.0
MEDIAN =	76.0	MEDIAN =	.	MEDIAN =	48.0	MEDIAN =	.	MEDIAN =	62.0
N =	1	N =	0	N =	1	N =	0	N =	2

* Type I w/ oxidation
** Type I w/o oxidation

system can achieve. Simply stated, this level is the minimum variability which can be practically obtained assuming proper system design, management, operational control, sampling and measurement.

Effluent variability can be characterized by the statistical analysis of daily data from well-operated treatment systems. The daily data computer file available for this analysis contains daily BOD, TSS, COD and TOC influent and effluent measurements over variable periods of records from three months to five years. The data base includes records for 50 plants. Although some records were as short as three months, most were for a period of at least one year. Before performing the variability analysis, however, it was necessary to screen the 50 plants to identify those exhibiting acceptable treatment system performance and using proper sampling procedures. This data screening involved the complementary statistical and engineering analyses described below.

The statistical screening for each plant was based on summary statistics, plots of daily concentrations versus time, and plots of moving summary statistics. Examples of the plots produced are given in Figures 7-5 and 7-6. The most useful statistical screening tool was the plot of the moving 12-month 99th percentile illustrated in Figure 7-6. The first point represents the estimated 99th percentile of data from the first 12 months. Succeeding points represent estimated 99th percentiles of data from months 2-13, 3-14, etc. This plot reflects changes in either the mean or variance of effluent concentrations over time. Plots for both BOD and TSS were produced for each plant based on the lognormal distribution.

Three types of plots were identified in studying the moving 99th percentile (Y0.99) plots:

Type I: Performance improved over time (there was a time after which Y0.99 decreased).

Type II: Performance worsened over time (there was a time after which Y0.99 increased).

Type III: There was a data gap due to modifications in the treatment system (generally followed by improved performance).

Table 7-36 shows the classification for each plant for BOD and TSS, along with beginning and ending dates and dates of data gaps (if any). Data from plants with Type I or III graphs for both BOD and TSS were tentatively accepted for further engineering analysis. Data from plants with Type II graphs were examined to determine if some cause for the worsening performance could be identified.

An engineering analysis also was conducted on each of the 50 candidate plants with daily data. The analysis consisted of a detailed review of each plant diagram and other information relevant to plant operation and performance. Specific points of interest included the relationship of the effluent sampling site to mixing points for stormwater runoff, untreated process water and cooling water, as well as modifications to the

FIGURE 7-5

MOVING SUMMARY GRAPH TYPES

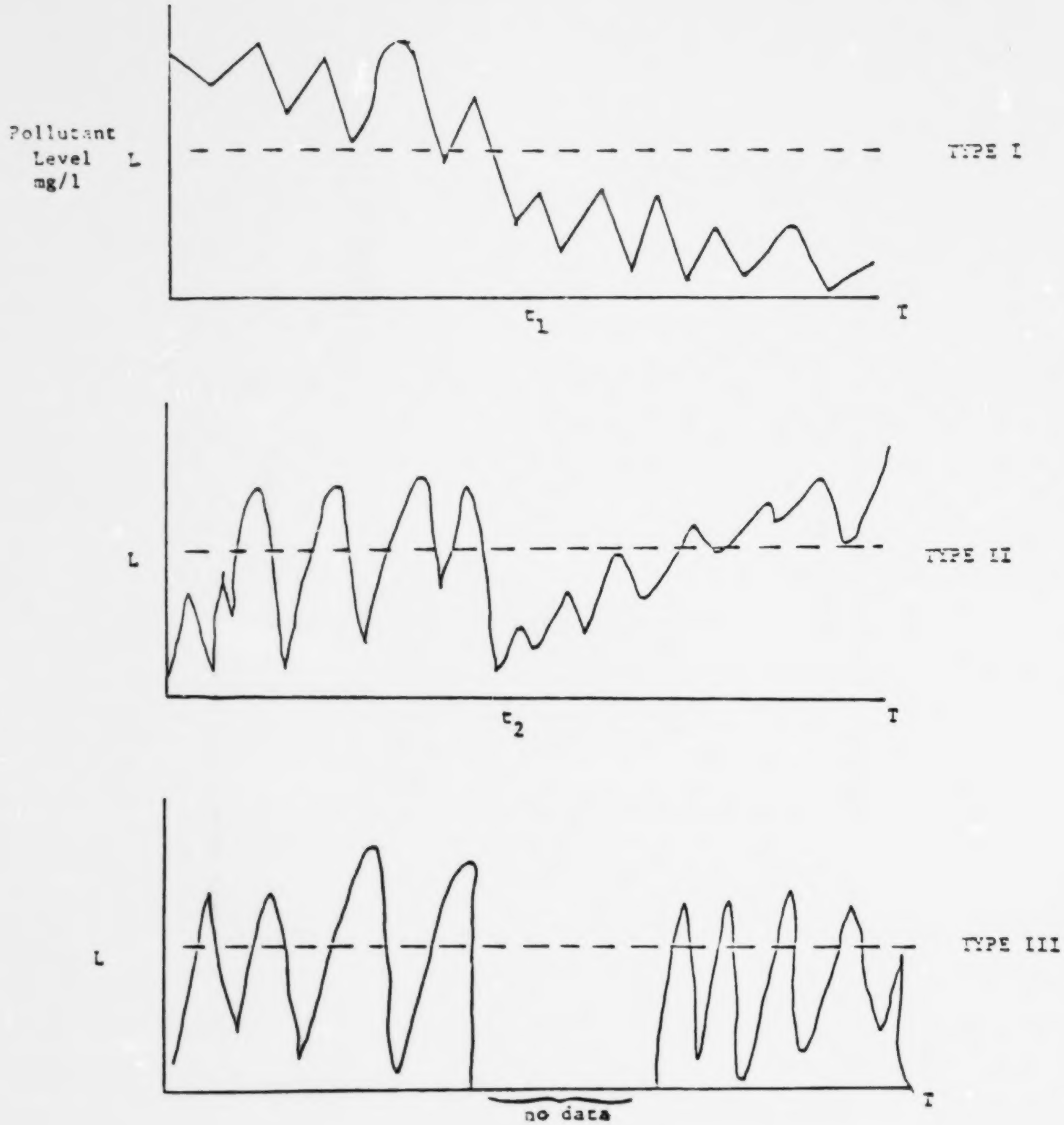
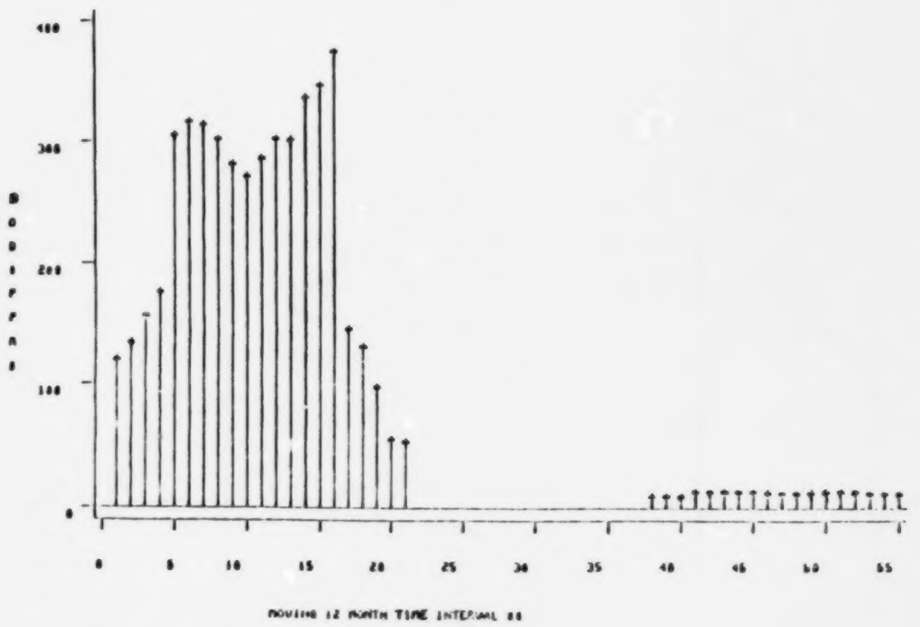


FIGURE 7-6 PLOT OF ESTIMATED 99th PERCENTILES vs. MOVING TIME INTERVALS

PLANT-45 STREAM- 1



** (1 = THE 1ST 12 MONTHS, 2 = THE 2ND-13TH MONTHS, ETC...)

TABLE 7-36

SUMMARY OF PLANT SCREENING

BOD

Plant	Stream	Type	Begin Date	Data Gap	End Date
1	A01	I	01/02/75	---	09/29/76
1	A02	III	01/01/75	10/76 - 05/79	07/30/79
3	A01	III	01/04/77	09/76 - 12/76	05/29/80
9	A01	I	01/15/75	---	09/22/76
292	A01	I	01/01/78	---	12/29/78
15	A01	I	01/01/78	---	05/31/80
18	A01	II	07/02/75	---	09/20/76
293	A01	I	01/03/75	---	09/24/76
27	A01	III	04/04/78	05/78 - 08/78	08/21/80
28	A01	II	09/03/75	---	09/30/76
42	A01	II	01/17/79	---	07/17/80
44	A01	I	01/01/79	---	05/30/80
45	A01	II	01/02/79	---	06/26/80
53	A01	I	01/02/75	---	09/30/76
60	A01	II	01/01/78	---	04/30/80
61	A01	I	01/03/75	---	09/30/76
73	A01	II	05/02/75	---	06/25/76
75	A01	I	08/02/74	---	05/31/76
89	A01	II	05/01/74	---	09/30/76
90	A01	I	01/02/75	---	09/30/76
96	A01	I	01/01/75	---	09/27/76
106	A01	I	01/07/75	---	10/31/76
109	A01	I	05/01/74	---	09/30/76
110	A01	II	01/03/75	---	09/30/76
111	A01	I	01/04/77	---	12/29/77
113	A01	I	01/01/78	---	12/31/79
118	A01	I	01/01/79	---	12/31/79
120	A01	I	04/01/76	---	09/29/76
124	A01	II	01/01/75	---	09/28/76
126	A01	I	01/02/75	---	09/30/76
138	A01	I	01/05/79	---	12/30/79
146	A01	III	01/02/75	10/76 - 04/79	07/31/79
170	A01	II	06/04/78	---	05/29/80
175	A01	II	01/03/78	---	07/11/80
176	A01	I	08/01/78	---	10/31/78
220	A01	II	01/02/75	---	09/24/76
229	A01	I	09/01/74	---	09/30/76
234	A01	I	01/03/78	---	12/27/79
236	A01	III	05/01/78	03/79 - 05/79	06/25/80
245	A01	I	05/21/77	---	04/29/80
268	A01	II	01/01/79	---	07/31/80
269	A01	II	01/04/75	---	09/29/76
274	A01	I	01/01/75	---	06/30/80
281	A01	I	07/02/78	---	06/29/80

TABLE 7-36 (Continued)

SUMMARY OF PLANT SCREENING

TSS

Plant	Stream	Type	Begin Date	Data Gap	End Date
1	A02	III	01/01/75	10/76 - 05/79	07/31/79
3	A01	II	01/01/77	---	05/29/80
9	A01	I	01/15/75	---	09/22/76
292	A01	I	01/01/78	---	12/30/78
18	A01	II	07/02/75	---	09/29/76
293	A01	I	01/03/75	---	09/24/76
27	A01	III	04/04/78	04/79 - 05/80	05/27/80
28	A01	II	09/02/75	---	09/30/76
44	A01	II	01/01/79	---	05/30/80
45	A01	I	01/01/79	---	06/30/80
53	A01	II	01/02/75	---	07/11/76
73	A01	II	05/05/75	---	06/25/76
89	A01	I	05/06/74	---	09/30/76
90	A01	I	01/01/75	---	09/30/76
96	A01	I	01/07/75	---	09/29/76
109	A01	I	06/18/74	---	07/26/74
110	A01	I	01/02/75	---	09/28/76
111	A01	I	01/01/77	---	12/31/77
113	A01	I	04/01/79	---	06/30/79
120	A01	I	04/01/76	---	09/29/76
123	A01	I	06/01/75	---	09/30/76
124	A01	I	01/01/75	---	09/28/76
126	A01	I	01/02/75	---	09/30/76
138	A01	I	01/01/70	---	12/31/79
146	A01	III	01/01/75	10/76 - 04/79	07/31/79
176	A01	I	08/01/78	---	10/31/78
220	A01	I	01/03/75	---	09/27/76
229	A01	I	09/01/74	---	09/30/76
236	A01	I	06/01/78	---	06/29/80
245	A01	I	06/21/77	---	04/29/80
274	A01	III	01/01/75	09/76 - 05/78	06/30/80
294	A01	I	01/01/79	---	12/31/79

treatment system during or after the period of data collection. A summary of the engineering analysis is presented in Table 7-37. This table provides the engineering comments and the nature of the reason for exclusion, where applicable, for each of the 50 candidate plants. A poor performer has been defined as a plant not achieving 95% BOD removal or an effluent of 50 mg/l BOD.

Based on the engineering and statistical analyses, 17 of the 50 plants were retained for further analysis. Appendix D contains a description of these plants and the reasons for exclusion. Because treatment system performance generally improved over time in the selected plants, the data retained in the final Daily Data Base for each plant were limited to samples collected within 12 months of the last sampling date.

Having selected daily data representing the performance of well-operated treatment systems, the next step was to find a statistical model to characterize effluent variability. The distributional model most commonly employed for daily measurements of BOD and TSS is the lognormal distribution. This model tends to be appropriate because distributions of daily pollutant measurements have a lower bound of zero, are positively skewed, and have standard deviations proportional to their means. To ensure that the lognormal model was appropriate for the data in the Daily Data Base, distributions of daily data were plotted and goodness-of-fit tests were run for each plant/pollutant data set. The goodness-of-fit test employed is described in Appendix B. The results of these analyses supported the use of the lognormal model.

Finally, effluent variability was characterized for BOD and TSS for each plant in terms of the variability factor--the ratio of the 99th percentile of the concentration to its long-term average for the daily maximum and the ratio of the 95th percentile of the concentration to its long-term median for the 30 day average. The methods used to estimate daily and 30-day average variability factors are described in Appendix B. The daily variability factors were based on the lognormal model, and the 30-day variability factors on the Central Limit Theorem (taking day-to-day correlation into account). The daily and 30-day variability factors calculated for each parameter and plant-specific data set in the Daily Data Base are presented in Tables 7-38 and 7-39. These summary tables provide the number of observations (N), the estimated mean, 99th percentile (P0.99), 95th percentile (P0.95), daily variability factor (VF(1)) and 30 day variability factor (VF(30)).

The variability factors were summarized separately for two categories of plants, Plastics Only and Not Plastics Only. The decision to use two categories, rather than determine a single set of factors for the entire OCPS industry, was based on the lower effluent BOD_5 levels achieved by Plastics Only plants relative to the rest of the OCPS plants. Further partitioning of the Not Plastics Only segment for the purpose of calculating variablity factors did not appear warranted since all plants use biological treatment as the major treatment technology. In addition, further partitioning would have effectively reduced the available data base for each group.

TABLE 7-37

SUMMARY OF ENGINEERING ANALYSIS

PLANT	>95%R or <50 mg/l	EXCLUDED FROM ANALYSIS	ENGINEERING COMMENTS AND/OR NATURE OF AND REASON FOR EXCLUSION
1	yes	yes	Treatment system upgraded during first data collection period; second data period too short for analysis.
3	yes	yes	Plant had upsets and bypasses continuously; poor operation,(o) system modification during data period.
9	yes	no	None
292	-	yes	Receives significant amount of municipal waste of unknown quantity.
15	yes	no	None, BOD only
18	yes	yes	Treatment system under construction during period of performance, effluent data not representative.
293	no	yes	Plant is a poor performer(o) due to inadequate solids control (66% removal TSS)
20	-	yes	No effluent data on BOD, COD or TSS
24	-	yes	No effluent data on BOD, COD or TSS
27	-	no	None
28	yes	yes	Chlorination before trickling filter, no longer manufactures organic chemicals.
42	no	yes	Poor performance plant;(o) poor operating practices, upset operations during data period.
44	yes	no	Treatment system changed prior to 1/79.
45	yes	no	None
53	yes	yes	Treatment system inadequate for average loadings, resulting in poor performance(o) and subsequent upgrade of system after data period.
60	no	yes	BOD only

TABLE 7-37 Continued

PLANT	>95%R or <50 mg/1	EXCLUDED FROM ANALYSIS	ENGINEERING COMMENTS AND/OR NATURE OF AND REASON FOR EXCLUSION
61	no	yes	Poor performance plant;(o) filtration unit added after period of performance in order to improve solids removal.
72	-	yes	No effluent data on BOD and TSS
73	yes	yes	Plant phased out a process during data period, resulting in drop of 70% BOD load during period of record.
74	-	yes	No effluent data on BOD, COD or TSS
75	yes	yes	Effluent sample point downstream of point where stormwater and cooling water are mixed with contaminated wastewater.
87	-	yes	Sample point is downstream of nonbiotreated effluent dilution, BOD and TSS data unavailable.
89	yes	yes	Sample point downstream of untreated process water dilution.
90	yes	yes	Sample point downstream of cooling water dilution.
96	yes	no	None
103	-	yes	No effluent data on BOD or TSS
106	yes	yes	Sample point downstream of cooling water dilution.
109	yes	yes	Effluent contains unquantified dilution from a "consolidated" sump.
110	yes	no	None
111	yes	no	None
113	yes	no	None
118	yes	no	None
120	yes	yes	Treats refinery wastewater with OCPS wastewater.

TABLE 7-37 Continued

PLANT	>95%R or <50 mg/1	EXCLUDED FROM ANALYSIS	ENGINEERING COMMENTS AND/OR NATURE OF AND REASON FOR EXCLUSION
123	-	yes	Sample point downstream of stormwater dilution (no BOD data).
124	yes	yes	Sample point downstream of stormwater mixing point.
126	yes	no	None
138	no	yes	Poor performer(o)
146	yes	yes	Sample point downstream of stormwater dilution.
170	yes	no	BOD data only
175	yes	no	None
176	yes	yes	Only three months of data available
220	yes	no	None
234	yes	no	None, data is for secondary system only.
236	yes	no	None
245	yes	yes	Non-biological treatment
268	no	yes	None
269	no	yes	Poor plant performance(o) appears due to plant being undersize; plant has upgraded treatment since data period.
274	-	yes	Significant portion of wastewater treated is sanitary flow.
294	-	yes	Poor performance(o) is due to poor solids control, especially for plant with sand filtration.
281	yes	no	None

(o) Poor performance is defined as not achieving 95% BOD removal or 50 mg/1 effluent BOD.

TABLE 7-38

ESTIMATES OF VARIABILITY FACTORS "PLASTICS ONLY" PLANTS

	Effluent BOD						Effluent TSS					
Plant	N	$\overline{X}$	PO.99	PO.95	VF(1)	VF(30)*	N	$\overline{X}$	PO.99	PO.95	VF(1)	VF(30)
9	24	5.84	17.88	-	3.06	-	24	29.72	97.58	-	3.28	-
44	261	8.97	29.51	11.84	3.29	1.32	260	11.58	80.50	19.76	6.95	1.71
45	156	3.07	10.67	4.28	3.47	1.39	364	18.95	124.62	30.87	6.57	1.63
96	105	2.31	7.86	-	3.41	-	66	12.34	45.26	16.05	3.67	1.30
111	157	6.19	18.38	9.25	2.97	1.49	347	10.42	54.12	14.84	5.19	1.42
126	249	6.05	23.70	10.23	3.92	1.69	253	23.28	78.35	31.10	3.37	1.34
				AVG	3.35	1.47				AVG	4.84	1.48

* Where there was insufficient data to estimate day-to-day correlation, no VF(30) value is given.

TABLE 7-39

ESTIMATES OF VARIABILITY FACTORS "NOT PLASTICS ONLY" PLANTS

	Effluent BOD						Effluent TSS					
Plant	N	$\overline{X}$	PO.99	PO.95	VF(1)	VF(30)*	N	$\overline{X}$	PO.99	PO.95	VF(1)	VF(30)
15	363	16.88	63.55	22.80	3.77	1.35						
26	160	17.55	68.26	26.69	3.89	1.52	158	21.86	76.32	28.99	3.49	1.33
110	247	5.91	21.82	8.37	3.69	1.42	218	10.09	45.33	14.37	4.49	1.42
113	332	17.47	75.06	28.95	4.30	1.66	91	22.41	100.27	31.22	4.48	1.39
118	365	12.17	61.34	25.25	5.04	2.07						
170	103	33.90	145.75	74.51	4.30	2.20						
175	361	39.09	181.49	69.66	4.64	1.78						
220	55	55.13	291.35	-	5.28	-	149	94.09	441.22	-	4.69	-
234	157	11.58	41.60	16.74	3.59	1.45						
236	162	32.19	93.17	39.75	2.89	1.23	362	59.72	159.29	72.55	2.67	1.21
281	205	8.44	26.73	11.62	3.17	1.38						
				AVG	4.05	1.61				AVG	3.95	1.34

*Where there was insufficient data to estimate day-to-day correlation no VF(30) value is given.

WASTEWATER DISPOSAL

The method of treatment for the direct dischargers was discussed under the previous heading. Under this heading the treatment processes and disposal methods associated with zero or alternate discharge in the OCPS industry are described.

Zero or Alternate Discharge

Zero or alternate discharge is defined as no discharge at the OCPS plant of contaminated process wastewater to either surface water bodies or to POTWs. Means by which zero or alternate discharge may be achieved are described in the following paragraphs.

Deep Well Disposal

Deep well injection is a method frequently used for disposal of highly contaminated or very toxic wastes not easily treated or disposed of by other methods. Deep well injection is limited geographically because of the geological requirements of the system. There must be a substantial and extensive impervious caprock strata overlying a porous strata which has no utility as a water supply or other withdrawal.

Because of the potential hazard of contaminating useable aquifers, some states prohibit the use of deep well disposal. Contamination of these aquifers can occur: (1) from improperly sealed well casings which allow the waste to flow up the bore hole, and (2) from unknown faults and fissures in the caprock which allow the waste to escape into the useable stratum. The latter is conceivable even though the fault may be miles from the well and the migration of the waste material to the fault might take many years. This problem could be enhanced by the increased subterranean pressure created by the injection well and could be further enhanced if a substantial withdrawal of water from the useable aquifer were made in the vicinity of the caprock flow.

Deep wells are drilled through impervious caprock layers into such unusable strata as brine aquifers. The wells are usually more than 3,000 ft deep and may reach levels over 15,000 ft. Pretreatment of the waste for corrosion control and especially for the removal of of suspended solids is normally required to avoid plugging of the receiving strata. Additional chemical conditioning could be required to prevent the waste and the constituents of the receiving strata from reacting and causing plugging of the well.

Because of the relatively high pressures required for injection and dispersion of the waste, high pumping costs for deep well disposal may be incurred.

A total of 20 plants in the Summary Data Base practice deep well injection. The wastes disposed of in this manner are fairly concentrated with mean BOD, TSS and COD of 3368 mg/l, 4301 mg/l and 14,242 mg/l, respectively.

Contract Hauling

Another method of achieving zero discharge is contract removal and disposal. This method involves paying a contract hauler/disposer to pick up the wastes at the generation site and to haul them to another site for treatment or disposal. The hauling may be accomplished by truck, rail or barge.

Contract hauling is usually limited to low volume wastes, many of which may require highly specialized treatment technologies for proper disposal. Although plants utilizing this technology are defined as zero dischargers, an impact on the environment may not be eliminated since the wastes are relocated only from the generating site and may be treated and discharged elsewhere. Reported data regarding contract disposal indicates that there are 15 plants using this disposal method in the Summary Data Base.

Offsite Treatment

Offsite treatment refers to wastewater treatment at a cooperative or privately owned centralized facility. Offsite treatment and disposal are used by plants that do not choose to install and operate their own treatment facilities. The rationale for utilization of offsite treatment usually is economically oriented and governed by the accessibility of suitable treatment facilities willing to treat the wastes (usually on a toll basis). Sometimes adjacent plants find it more feasible to install a centralized facility to handle all wastes from their facilites. The capital and operating costs usually are shared by the participants on a pro-rata basis.

Depending on the nature of the waste and/or the restrictions imposed by the receiving treatment plant, wastes sent for offsite treatment may require pretreatment at the generating plant. Four plants in the Summary Data Base practice off-site treatment.

Incineration

Incineration is a frequently used zero-discharge method in the OCPS industry. Depending upon the heat value of the material being incinerated, incinerators may or may not require auxiliary fuel. The gaseous combustion or composition products may require scrubbing, particulate removal, or another treatment to capture materials that cannot be discharged to the atmosphere. This treatment may generate a waste stream that ultimately will require some degree of treatment. Residue left after oxidation will also require some means of disposal.

Incineration is usually used for the disposal of flammable liquids, tars, solids, and/or hazardous waste materials of low volume and not amendable to the usual EOP treatment technologies. In all, seven plants in the Summary Data Base employ incineration. Only three data points were reported for incineration. The average of those data showed a waste BOD of approximately 25,000 mg/l.

Evaporation

Evaporation is used in the OCPS industry to reduce the volume of waste water and thereby concentrate the organic content to render it more suitable for incineration or disposal to landfill. This technology is normally used as in-plant treatment or pretreatment for incineration or landfill.

Evaporation equipment can range from simple open tanks to large, sophisticated, multi-effect evaporators capable of handling large volumes of liquid. Typically, steam or some other external heat source is required to effect vaporization. Therefore, the major limitations to mechanical evaporation is the amount of energy required.

Only two OCPS plants, both exclusively plastics, reported evaporation as their principal disposal method.

Impoundment

Impoundment generally refers to wastewater storage in large ponds. Alternate or zero discharge from these facilities relies on the natural losses by evaporation, percolation into the ground, or a combination thereof. Evaporation is generally feasible if precipitation, temperature, humidity and wind velocity combine to cause a net loss of liquid in the pond. If a net loss does not exist, recirculating sprays, heat or aeration can be used to enhance the evaporation rate to provide a net loss. The rate of percolation of water into the ground is dependent on the subsoil conditions of the area of pond construction. Since there is a great potential for contamination of the shallow aquifer from percolation, impoundment ponds are frequently lined or sealed to avoid percolation and thereby make the basins into evaporation ponds. Solids which accummulate over a period of time in these sealed ponds will eventually require removal. Land area required for impoundment is a major factor limiting the amount of flow disposed by this method.

Twelve plants in the Summary Data Base use impoundment for wastewater disposal. The wastewaters handled in this way are relatively concentrated having average BOD, TSS and COD levels of about 2700, 2000 and 7500 mg/l, respectively.

Land Disposal

There are two basic types of land disposal: landfilling and land application (or spray irrigation). Landfilling consists of dumping the wastes into a pit and subsequently burying them. Land application requires spraying the wastes over land. Both disposal methods require care in selecting the site to avoid any possibility of contaminating ground and surface water. The type of pollutant being disposed by land application also must be considered. For instance, if the land is to be used for growing crops at a later time, some of the pollutants present at the time of application may persist in the soil for long durations and later may be assimilated by the crops and find their way into the food chain.

Four plants in the Summary Data Base practice land disposal.

SECTION VIII.

ENGINEERING COSTS AND NON-WATER QUALITY ASPECTS

INTRODUCTION

This section addresses the cost, energy requirements and non-water quality environmental impacts associated with meeting BPT effluent guidelines. The cost estimates represent incremental expenditures required to supplement the control and treatment technology presently in place. Cost estimates have been prepared using a modified version of the CAPDET computer costing algorithm. Non-water quality aspects reviewed include the potential for (a) air pollution, (b) solid waste generation, (C) RCRA considerations, (d) noise pollution, and (e) energy requirements.

COST DEVELOPMENT

In order to estimate the industry expenditures required to meet alternative effluent targets, and as a partial basis for economic studies, a plant-by-plant cost analysis has been made. Capital, operating and annual costs were developed for each of the plants that supplied sufficient information to the Summary Data Base. For each plant, the cost of applying various treatment technology alternatives to meet selected target concentrations for BOD and TSS was conducted.

The basic calculation tool used to develop alternative engineering costs (with the exception of RBC costs) is the computer program, CAPDET (Computer Assisted Procedure For the Design and Evaluation of Wastewater Treatment Facilities). The CAPDET computer model was developed jointly by the Corps of Engineers' Waterway Experiment Station, Vicksburg, Mississippi and the EPA Office of Water and Waste Management. The major purpose of the CAPDET model is to provide for the rapid design, cost estimating and ranking by cost of municipal sewage treatment plant alternatives for the EPA Construction Grants Program. The model may be used for the design of industrial wastewater treatment systems by modifying selected computer program default values. A detailed discussion of the design and application of the CAPDET program is presented in Appendix E.

CAPDET MODIFICATIONS

Development of the specific costs applicable to this study requires adaptation of many of the factors in the program from their default values for municipal systems to values more appropriate to chemical industrial wastewater and to industrial plant situations. Table 8-1 summarizes the quantitative bases and default values employed, reflecting those adjustments considered necessary for an industrial wastewater system.

Because of the varying complexity and biodegradability, as well as the generally lower biodegradability of industrial wastewaters as opposed to the essentially constant treatability of domestic wastewater, reaction rate coefficients must be adjusted from CAPDET default values. A

TABLE 8-1

ADJUSTMENTS TO CAPDET DEFAULT
DATA AND RESULTS

PROCESS	CAPDET VALUE	ADJUSTED VALUE	DEFAULT OR RESULT
ASL	k = 0.00135 l/mg/hr	$k = \frac{5\ /\ day\ /\ 1}{day/24hr/So\ mg}$ Where: So = BOD Influent Concentration	DEFAULT
ALA	k = 0.001 l/mg/hr	$k = \frac{5\ /\ day\ /\ 1}{day/24/hr/So\ mg}$	DEFAULT
PRIMARY CLARIFIER ("IN" "ASL" AND "ALA" TRAINS)	BOD % Removal = 32%	BOD % Removal = 10%	DEFAULT
DAF, CLAR	Land Result Based on $1000/acre	Land Result Based on Dimensions of Unit at $10,000 per acre	RESULT
	Laboratory Labor Based on Flow	Laboratory Labor Based on Proration of $50,000/yr for 1 man per an entire waste Treatment Plant	RESULT
	Administrative Costs Based on Flow	Administrative Costs Equal to 15 percent of of/maint. labor	RESULT
ALL UNITS	201 Planning Indirect Cost Equal TO 3.5% of Construction Cost and Contingency Equal to 8%	Delete 201 Planning and Adjust Contingency to 11.5% of Construction Costs	

reaction rate coefficient of 5.0 $days^{-1}$ is used to represent organic chemical wastewater. In the primary clarification segment of the activated sludge process the percent BOD reduction is taken as 10 percent, rather than the default value of 32 percent. These changes adapt CAPDET's approach to the design of organic chemical industrial wastewaters. Alternative cost factors were needed for certain limited scope treatments to avoid the flow-loaded factors applicable to complete systems. Administrative costs for clarification and dissolved air flotation were set at 15 percent of the operating and maintenance labor costs.

Laboratory labor was also adjusted to reflect discrete unit manpower requirements for clarification and dissolved air flotation processes. Laboratory charges are based on the use of one full-time individual for an entire waste treatment system. The approximate annual cost is $50,000. Costs are prorated over the various treatments and assumed constant, whether the flow volume treated was high or low. The hourly laboratory charges include analyst's base pay plus overtime, fringe benefits, lab equipment and materials and miscellaneous overhead burdens.

The availability of land and its valuation varies markedly with site specific conditions. If land is available on the site, its potential future use and opportunity cost should be considered. If land is not available, purchase of the necessary acreage must be considered. The CAPDET default value of $1000 per acre is judged to be substantially on the low side, possibly several times too low. Where appropriate, if land costs were a factor in the technology costs, both acreage and cost per acre were separately estimated and inserted to override in the program. In these cases estimated acreage costs of $10,000 per acre were used to represent the industrial value of land.

In developing the cost analysis, the cost of upgrading an existing treatment facility is assumed to be approximated by the cost of second stage treatment as an addition to the existing facilities. This represents a conservative approach to cost development in that it reflects the maximum cost of upgrading an existing system. In many cases, less expensive treatment system modifications, improved operating practices, or application of in-plant source control techniques may achieve equal or better results at a lower cost. However, in the absence of extensive plant-by-plant design details, second stage or add-on treatment was used as the cost basis. True costs will depend significantly on factors site specific for each plant.

Other considerations when applying CAPDET to industrial treatment estimates are as follows:

1. Unless changed by the user, CAPDET uses default values for conventional pollutant concentrations and other stream characteristics. Also, for each treatment process, specific relationships exist for the removal of the conventional pollutants. For example, the long term mean (LTM) TSS in the activated sludge model is reported at the raw wastewater influent as 200 mg/l (LTM) and at the final clarifier effluent as 20 mg/l (LTM). For industrial wastewaters, a final effluent of 20 mg/l

(LTM) may be optimistic and is more likely to be in the range of 30 to 50 mg/l (LTM) unless flocculants or other settling aids are used. Some of the CAPDET values were found to be suitable for industrial wastewater treatment calculations and consequently were not revised. The influent and effluent values for the other characteristics (COD, O&G, TOC, etc.) are reported as noted in Tables 8-2 and 8-3; however, these values do not affect the cost estimates and are included in CAPDET primarily for municipal planning purposes.

2. The cost estimates are generated for average flows. A common engineering design practice is to determine the flow and other parameter variability, and design on a basis of an 80 to 95 percentile value. The exact design value chosen is determined by the range of variability of the parameter and the subjective opinion of the engineer. Built into the evaluation is a long range corporate objective or plan pertaining to future expansions, changes in product lines and similar factors which might affect the various parameters associated with the design. Since these factors were not available, the average flow values were used as a basis for the cost estimates. However, since the cost curves show ranges of parameter values, costs for any flow can be derived for any individual plant. Furthermore, CAPDET has built-in Excess Capacity Factor equations which allow for peak flow vs. average flow performance in calculating the detention times and other design factors of the technologies.

3. The cost generated by CAPDET for activated sludge and aerated lagoons appear to be insensitive to changes in target effluent BOD concentrations when the influent concentration is less than 500 mg/l. This phenomenon is created by the fact that the CAPDET model introduces a second equation for aeration detention time calculation at the 500 mg/l influent concentration and selects the larger value of the two.

The formula used for the detention time calculations when the influent BOD concentration is greater than 500 mg/l is:

$$t = (1-S_e/S_o) / (S_e/S_o\ k\ X_v) \qquad (1)$$

Where:

t = detention time, hours

S_e = effluent BOD concentration, mg/l

S_o = influent BOD concentration, mg/l

k = reaction rate constant 1/mg hr

Xv = mixed liquor volatile suspended solids, mg/l

When the specific influent BOD concentration is below 500 mg/liter, the following equation is added, the retention time calculated by both methods, and the greater time is reported:

TABLE 8-2

CAPDET DEFAULT INFLUENT WASTE CHARACTERISTICS

TEMPERATURE	18.0	°C
SUSPENDED SOLIDS	200	mg/l
VOLATILE SOLIDS	60	% of SS
SETTLEABLE SOLIDS	15	mg/l
BOD_5	250	mg/l
SBOD	75	mg/l
COD	500	mg/l
SCOD	400	mg/l
pH	7.6	
CATIONS	160	mg/l
ANIONS	160	mg/l
PO_4	18	mg/l
TKN	45	mg/l
NH_3	25	mg/l
NO_2	0	mg/l
NO_3	0	mg/l
OIL AND GREASE	80	mg/l

TABLE 8-3

WASTE CHARACTERISTIC REMOVAL DEFAULT VALUES FOR CAPDET PROCESSES

PROCESS	WASTE CHARACTERISTIC REMOVALS							
	BOD_5	TSS	COD	OIL & GREASE	TKN	PHOS	NH_3	SETTLEABLE SOLIDS
Dissolved Air Flotation	30%	80%	30%	-	10%	-	-	-
Primary Clarification	32%	58%	40%	-	5%	5%	-	-
Activated Sludge	USER INPUT INFLUENT AND EFFLUENT	USER INPUT TO SECONDARY CLARIFIER	1.5 x BOD_{EFF}	0	30%	30%	SET EQUAL TO TKN	0
Aerated Lagoon	USER INPUT INFLUENT AND EFFLUENT	USER INPUT TO SECONDARY CLARIFIER	ASSUME		SAME AS ASL			
Multi Media Filtration	SET EFFLUENT EQUAL TO $BOD_{SOLUBLE}$ INFLUENT	60%	SET EFFLUENT EQUAL TO $COD_{SOLUBLE}$ INFLUENT	0	PASS ON THROUGH	PASS ON THROUGH	PASS THROUGH	0

$$t = (24\ S_o) / (X_v\ (F/M)) \qquad (2)$$

Where:

t = detention time, hours

S_o = influent BOD concentration, mg/l

X_v = mixed liquor volatile suspended solids, mg/l

F/M = food to microorganism ratio, lbs/day/lb
usually 0.3-0.6

In comparing equations (1) and (2) it should be noted that the detention time (t) in equation (1) is influenced by influent and effluent substrate concentrations, the reaction rate "k," and the reactor MLVSS. The detention time determined by equation (2) is a function of the influent substrate concentration, MLVSS and the F/M ratio. Since the detention time determined by equation (2) is theoretically independent of the effluent concentration, a single cost is determined for all effluent target levels considered.

Figure 8-1 compares the calcuated detention time determined by the two methods. The solid lines represent the result of applying equation (1) at various target levels. The dashed line presents the results of equation (2) with the same applied influent concentration. Note that the time curves from both equations merge as the influent BOD decreases in concentration. Since the CAPDET program uses the greater of the two values calculated for detention time, cost estimates for aerators will be slightly overestimated for wastewaters with influent BOD concentrations less than 500 mg/l (LTM) and effluent concentrations of 50 mg/l (LTM).

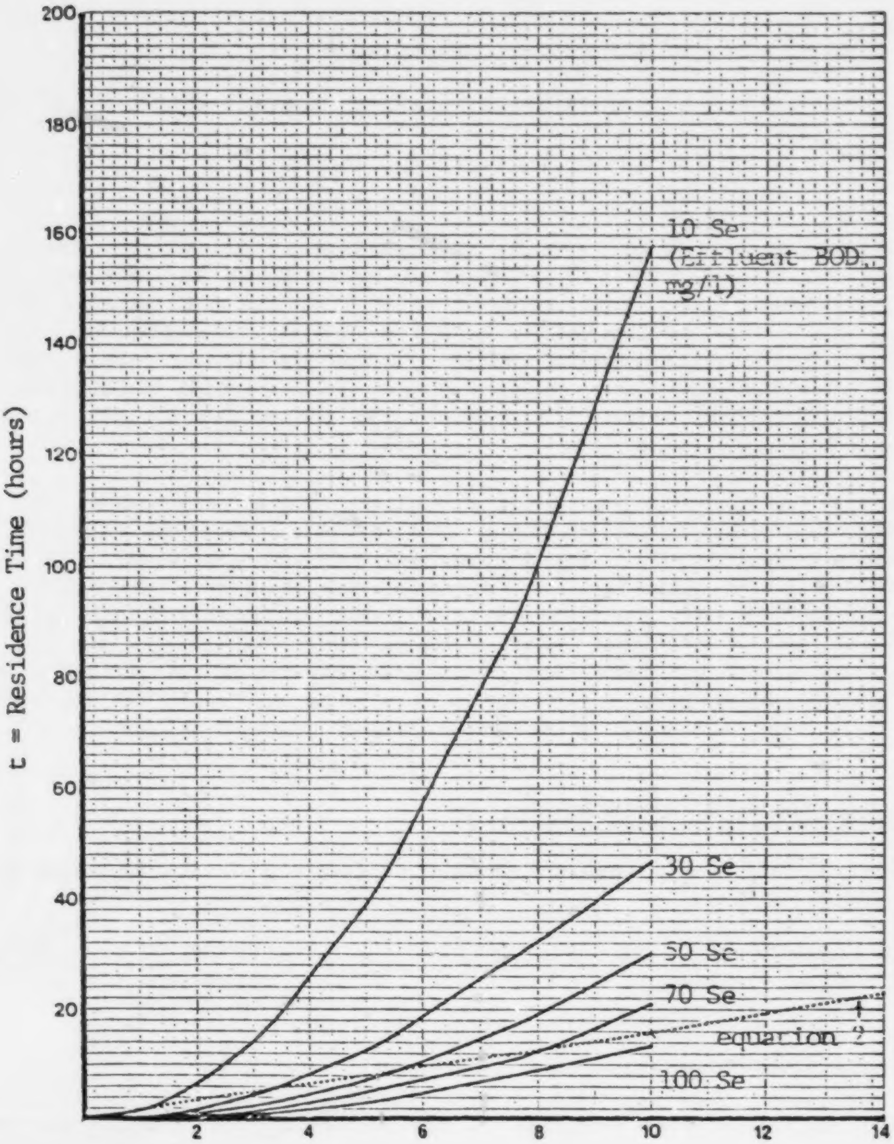
ESTIMATING DISCRETE UNIT COSTS

Engineering cost estimates are presented for the following wastewater treatment processes:

1. Dissolved air flotation
2. Clarification
3. Activated sludge
4. Aerated lagoon
5. Multimedia filtration

The cost estimates were prepared using the CAPDET model which was modified as previously indicated to reflect industrial rather than municipal treatment costs.

An example of the engineering costs determined by CAPDET for a typical treatment application are shown for each of the above unit processes in Tables 8-4 through 8-8. The installed cost of the machinery is shown by unit, in the second column, followed by the amortization cost for the individual equipment pieces. Because the life expectancy of different



So = Influent BOD Concentration (100 mg/l)

FIGURE 8-1 - AERATOR RETENTION TIME SENSITIVITY ANALYSIS

TABLE 8-4-COST SUMMARY, FLOTATION

Unit	Installed Equipment Cost $	Amort. Cost $/YR	Oper. Labor Cost $/YR	Maint. Labor Cost $/YR	Power Cost $/YR $0.04/KWH	Material Cost $/YR	Chemical Cost $/YR	Plant O&M Cost $/YR
Flotation	288,767	29,114	6,664	1,259	7,841	2,887	-0-	18,651
Total	288,767	29,114	6,664	1,259	7,841	2,887	-0-	18,651

TOTAL CONSTRUCTION COST $

DIRECT

Installed Equipment	288,767
Contractor OH & Profit	63,528
Total Direct	352,295

INDIRECT

Land	1,000	(0.1 acres)
Misc. Non Construction	17,614	
A/E Design Fee	31,733	(9.01% Const. Cost)
Inspection	7,045	
Technical Costs	7,045	
Admin/Legal	7,045	
Contingencies	40,513	
Total Indirect	111,995	
Total Direct and Indirect	464,290	

TOTAL O&M COST $/YR

Plant O&M Cost	18,651
Laboratory Cost	12,500
Administration	1,188
Total	32,339

EQUIVALENT ANNUAL COST $/YR

$66,889/YR

PLANT DESIGN BASIS

FLOW	4.0 MGD
INF TSS	200 mg/l
EFF TSS	40 mg/l

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TABLE 6-5-COST SUMMARY, CLARIFICATION (SEDIMENTATION)

Unit	Installed Equipment Cost $	Amort. Cost $/YR	Oper. Labor Cost $/YR	Maint. Labor Cost $/YR	Power Cost $/YR $0.04/KWH	Material Cost $/YR	Chemical Cost $/YR	Plant O&M Cost $/YR
Prim Cla	202,253	18,579	4,288	1,532	346	2,022	-0-	8,188
Total	202,253	18,579	4,288	1,532	346	2,022	-0-	8,188

TOTAL CONSTRUCTION COST $

DIRECT

Installed Equipment	202,253
Contractor OH & Profit	44,495
Total Direct	246,748

INDIRECT

Land	2,000	(0.2 acre)
Misc. Non Construction	12,337	
A/E Design Fee	24,055	(9.75% Const. Cost)
Inspection	4,934	
Technical Costs	4,934	
Admin/Legal	4,934	
Contingencies	28,375	
Total Indirect	81,569	
Total Direct & Indirect	328,317	

TOTAL O&M COST $/YR

Plant O&M Cost	8,188
Laboratory Cost	12,500
Administration	873
Total	21,561

EQUIVALENT ANNUAL COST $/YR

$60,100/YR

PLANT DESIGN BASIS

FLOW	4.0 MGD
INF TSS	200 mg/l
EFF TSS	80 mg/l

TABLE 8-6 COST SUMMARY, ACTIVATED SLUDGE

Unit	Installed Equipment Cost $	Amort. Cost $/YR	Oper. Labor Cost $/YR	Maint Labor Cost $/YR	Power Cost $/YR $0.04/KWH	Material Cost $/YR	Chemical Cost $/YR	Plant O&M Cost $/YR
Prim Cla	107,816	9,904	2,546	1,206	299	1,078	-0-	5,129
Pumping	92,868	9,926	3,200	2,170	2,679	650	-0-	8,699
S Sec Cl	145,374	13,354	3,184	1,458	309	1,453	-0-	6,404
Comp Mix	1,430,337	168,006	34,063	17,526	321,666	6,637	-0-	379,892
Grav Thc	61,984	5,694	2,288	1,534	247	619	-0-	4,688
Dry Beds	152,994	17,970	19,216	7,958	-0-	1,376	-0-	28,55[illegible]
Houl & Lf	81,402	36,706	1,771	-0-	-0-	11,234	-0-	13,005
Total	2,072,777	261,563	66,271	31,855	325,855	23,050	-0-	446,367

TOTAL CONSTRUCTION COST $

DIRECT

Installed Equipment	2,072,777
Contractor OH & Profit	456,010
Total Direct	2,528,787

INDIRECT

Land	9,485	(.95 acre)
Misc. Non Construction	126,439	
A/E Design Fee	169,827	(6.72% Const. Cost)
Inspection	50,575	
Technical Costs	50,575	
Admin/Legal	50,575	
Contingencies	390,809	
Total Indirect	848,285	
Total Direct & Indirect	3,377,072	

TOTAL O&M COST $/YR

Plant O&M Cost	446,367
Laboratory Cost	19,149
Administration	6,911
Total	472,427

EQUIVALENT ANNUAL COST $/YR

$875,296/YR

PLANT DESIGN BASIS

INF BOD	1000 mg/1
EFF BOD	30 mg/1
FLOW	1 MGD
EFF TSS	50 mg/1

TABLE 8-7-COST SUMMARY, AERATED LAGOON

Unit	Installed Equipment Cost $	Amort. Cost $/YR	Oper. Labor Cost $/YR	Maint. Labor Cost $/YR	Power Cost $/YR $0.04/KWH	Material Cost $/YR	Chemical Cost $/YR	Plant O&M Cost $/YR
Prim Trmt	170,064	16,098	13,915	5,741	1,859	4,251	-0-	25,766
Aer Lago	211,090	31,646	3,965	587	42,888	3,099	-0-	50,539
L Prm Cl	107,817	9,904	2,546	1,202	300	1,078	-0-	5,126
Two St L	556,842	65,406	-0-	16,129	-0-	1,824	-0-	17,953
L Prm Cl	107,817	9,904	2,546	1,202	300	1,078	-0-	5,126
Grav Thc	47,850	4,395	1,596	1,140	210	478	-0-	3,424
Dry Beds	90,568	10,638	11,181	4,616	-0-	815	-0-	16,612
Haul & Lf	68,410	30,847	1,030	-0-	-0-	11,234	-0-	12,264
Total	1,360,458	178,838	36,779	30,617	45,551	23,857	-0-	136,810

TOTAL CONSTRUCTION COST $

DIRECT

Installed Equipment	1,360,458
Contractor OH & Profit	299,301
Total Direct	1,659,759

INDIRECT

Land	22,000	(2.2 acres)
Misc. Non Construction	82,988	
A/E Design Fee	117,157	(7.06% Const. Cost)
Inspection	33,195	
Technical Costs	33,195	
Admin/Legal	33,195	
Contingencies	190,871	
Total Indirect	512,601	
Total Direct & Indirect	2,172,360	

TOTAL O&M COST $/YR

Plant O&M Cost	136,810
Laboratory Cost	28,649
Administration	28,414
Total	193,873

EQUIVALENT ANNUAL COST $/YR

$467,705

PLANT DESIGN BASIS

TABLE 8-8-COST SUMMARY,MULTIMEDIA FILTRATION

Unit	Installed Equipment Cost $	Amort. Cost $/YR	Oper. Labor Cost $/YR	Maint. Labor Cost $/YR	Power Cost $/YR	Material Cost $/YR	Chemical Cost $/YR	Plant O&M Cost $/YR
Filtrati	345,396	40,570	1,292	605	1,264	10,040	-0-	13,201
Pumping	142,710	15,254	3,825	2,202	10,684	998	-0-	17,709
Total	488,107	55,824	5,117	2,808	11,948	11,039	-0-	30,910

TOTAL CONSTRUCTION COST $

DIRECT		
Installed Equipment	488,107	
Contractor OH & Profit	107,373	
Total Direct	595,490	
Land	14,261	
Misc. Non Construction	29,774	
A/E Design Fee	48,106	(8.08% Const. Cost)
Inspection	11,909	
Technical Costs	11,909	
Admin/Legal	11,909	
Contingencies	68,481	
Total Indirect	196,349	
Total Direct & Indirect	791,839	

TOTAL O&M COST $/YR

Plant O&M Cost	30,910
Laboratory Cost	24,936
Administration	17,458
Total	73,304

EQUIVALENT ANNUAL COST $/YR

$164,561/YR

PLANT DESIGN BASIS

INF TSS	40 mg/1
EFF TSS	16 mg/1
AVG FLOW	4.0 MGD

pieces of equipment varies quite widely, CAPDET uses different amortization periods for different equipment. For example, the operating life expectancy of a pump may be 2 to 10 years, but a concrete structure such as a clarifier may have a life expectancy of 50 years. A listing of the life expectancy used by CAPDET for various treatment system components is presented in Table 8-9. This table also serves to define the unit process keywords shown in Tables 8-4 thru 8-8.

The lower part of the tables summarize the construction costs (direct and indirect), the operation and maintenance costs and the equivalent annual costs. Also included is the basis of the unit process design. Discrete unit cost curves for all treatment processes evaluated are in Appendix F.

Dissolved Air Flotation

In wastewater treatment, dissolved air flotation (DAF) is used as a clarification process to remove suspended solids, or oil and grease. It may also be used as a thickening process to concentrate various types of flotable sludges or scums.

The principal components of this system are a pressurizing pump, chemical mix tanks, air injection facilities, a retention tank, a backpressure regulating device and a flotation unit. The influent data used for the model includes wastewater flow and suspended solids concentration in the feed. Variations in both flow and concentration occur in industrial situations and consequently are considered in most designs; however, the governing parameter in the design of flotation units is the flow rate. Except in extreme cases, the solids concentration does not influence the size or operating cost of the unit.

CAPDET approximates BOD and COD removals in primary clarification and flotation at 30 percent each, with default influent values of 250 mg/l and 500 mg/l, respectively. These values are for estimation purposes for municipalities only and do not affect the costs of dissolved air flotation, which are primarily a function of flow rate.

Costs for polymer addition are included in this exercise as an option. The suggested usage of dissolved air flotation for solids removal is limited to effluent values of 50 mg/l (LTM) TSS. CAPDET assumes 80 percent removal of TSS and 30 percent removal of BOD. In practice, the reduction of suspended solids ranges from 70 to 95 percent with incidental BOD removal ranging from 10 to 50 percent. Table 8-4 is an example summary sheet for cost data at 4 MGD, and Figure 8-2 presents the cost versus flow curves from dissolved air flotation. Figure 8-2 presents costs with and without chemical addition.

Clarification

Clarification (sedimentation) is a solids-liquid process designed to remove suspended particles that are heavier than water. Primary clarifiers are normally used in conjunction with biological wastewater treatment systems to remove the settleable solids and a fraction of the BOD

TABLE 8-9

CAPDET UNIT PROCESS REPLACEMENT SCHEDULE

Unit Processes	Key word	Cost Item	Replacement Schedule (years)
Activated Sludge Units			
Complete Mix	COMPLE	Mechanical Aerator (RSSA)	20
Contact Stabilization	CONTAC	Diffuser (RSPD)	30
Extended Aeration	EXTEND	Swing Arm Diffuser (RSPH)	30
High Rate	HIGH R	Pump (RSPS)	25
Plug Flow	PLUG F	Structural (RSST)	40
Air Flotation	AIR FL	Air Flotation Unit (RSFS)	30
		Structural (RSST)	40
Aerated Lagoon	AERATE	Mechanical Aerator (RSSA)	15
		Liner (RSLL)	15
		Structural (RSST)	40
Chemical Feed Systems (Service life cannot be changed)	None	Alum System	40
		Iron Salts System	40
		Lime System	40
		Polymer System	40
Drying Beds	DRYING	4-in. Pipe (RSCP)	20
		6-in. Pipe (RSCP)	20
		8-in. Pipe (RSCP)	20
		Structural (RSST)	40
Equalization	EQUALI	Floating Aerator (RSSA)	15
		Liner (RSLL)	15
		Structural (RSST)	40
Filtration	FILTRA	Filter Unit (RSSF)	20
		Pump (RSPS)	25
		Package Filter Unit (RSSF)	20
		Structural (RSST)	40
Gravity Thickening	GRAVIT	Thickener (RSTS)	40
		Structural (RSSt)	40
Sludge Hauling and Land Filling	HAULIN	Vehicle (RSSV)	6
		Structural (RSST)	40
Lagoon	LAGOON	Steel Pipe (RSSP)	20
		Butterfly Valve (RSSV)	20
		Liner (RSLL)	15
		Structural (RSST)	40
Microscreening	MICROS	Microscreen (RSSM)	15
		Structural (RSST)	40

TABLE 8-9 (Continued)

Unit Processes	Key word	Cost Item	Replacement Schedule (years)
Primary Clarification			
Primary	PRIMAR	Mechanism (RSMS)	40
Two-Stage Lime	L PRIM	Structural (RSST)	40
Pumping	PUMPIN	Pump (RSPS)	25
		Structural (RSST)	40
Secondary Clarification			
General	CLARIF	Mechanism (RSMS)	40
Activated Sludge	A SECO		
Denitrification	D SECO	Structural (RSST)	40
Nitrification	N SECO		
Oxidation Ditch	O SECO		
Pure Oxygen	P SECO		
Trickling Filter	T SECO		

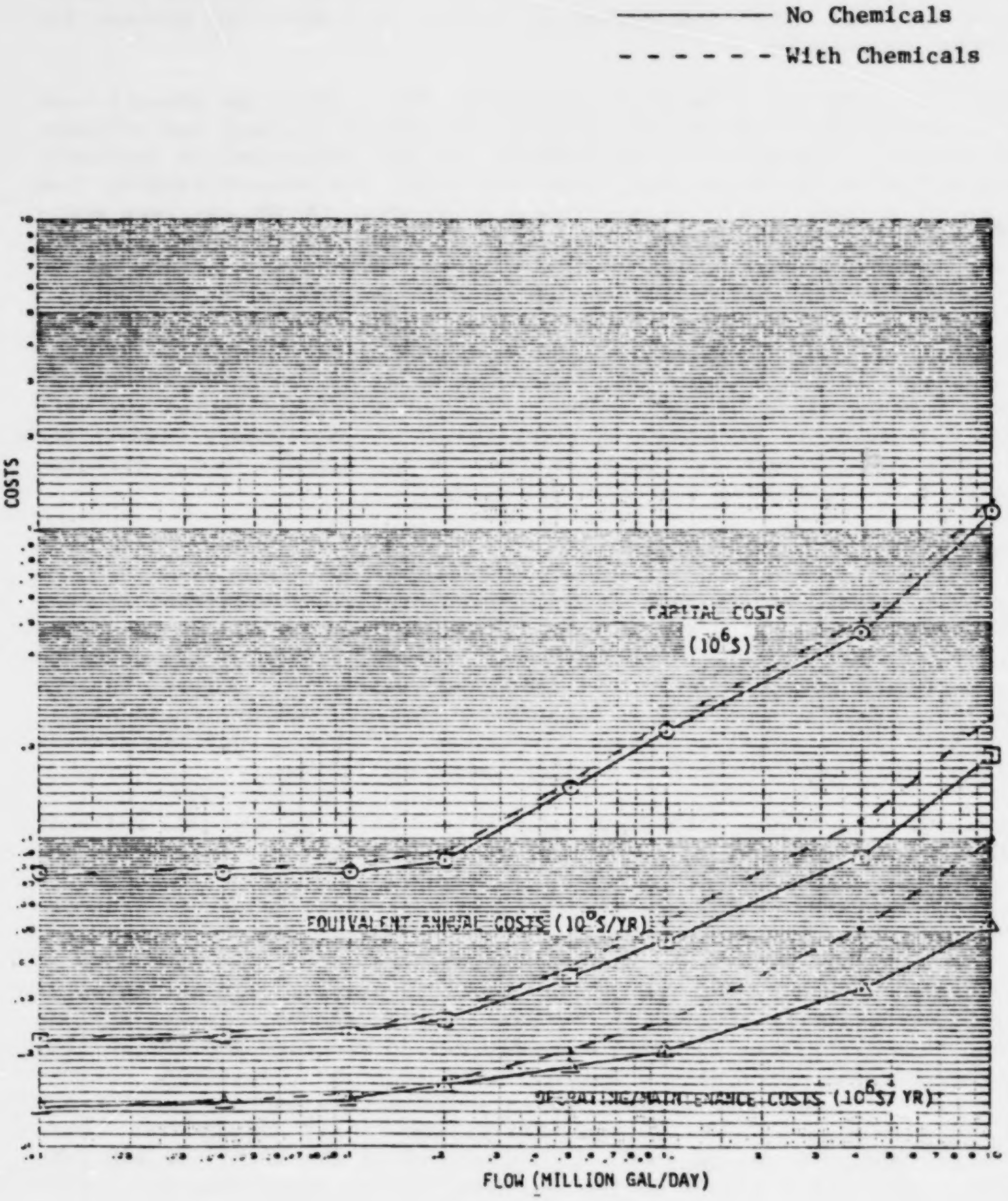

FIGURE 8-2 - CAPITAL, OPERATING AND ANNUAL COSTS DISSOLVED AIR FLOTATION

and thereby reduce the load on the biological systems. Secondary clarifiers are used after the biological system to remove the biomass for disposal or recycle.

Clarifier costs are related to wastewater flow, since the overall cost of a clarification unit is not greatly affected by influent and effluent TSS levels. Suspended solids removal through sedimentation typically ranges from 60 to 90 percent, with incidental BOD removal ranging from 10 to 40 percent.[8-1] As previously indicated, CAPDET has been modified to use a constant 10% BOD removal through primary clarification. Clarification with floculation can producet TSS levels as low as 30 mg/l. [8-2] The cost of polymer addition is included as an option.

Secondary clarification units following biological treatment systems represented in the summary data base achieve an effluent TSS concentration of about 35 to 60 mg/l (LTM). The cost of clarification for various flow rates is presented in Figure 8-3. A cost summary example for a 4 MGD waste stream is listed in Table 8-5. CAPDET uses a circular clarifier in developing a process design.

Complete Mix Activated Sludge

Activated sludge is the most commonly used biological treatment process for removing soluble and colloidal contaminants from process wastewaters.[8-3] One of several possible unit process sequences for complete mix activated sludge treatment of industrial wastewater is shown in Figure 8-4. This typical design includes a complete mix activated sludge unit with primary and secondary clarification, sludge recycle, gravity thickening, sludge drying and hauling, and landfilling.

The input data required by CAPDET for this technology includes influent BOD, flow and a target effluent BOD. Average values are considered and the flow is assumed to be constant. A detailed calculation procedure is employed by CAPDET using coefficients and constants, adjusted as necessary for industrial application, as shown in Table 8-1.

The use of average input values is judged to provide cost estimates of sufficient accuracy to provide the basis for an economic impact evaluation. Although in actual site specific design practice the variability in flow and raw wastewater characteristics would be considered, the excess capacity included in the design calculations depends upon a detailed statistical study of the variability of all parameters. Once this is made, the design basis is influenced by the intuitive and subjective evaluation of the design engineer, and in some cases by corporate policy.

As an alternative to exhaustive site specific analysis, CAPDET provides an Excess Capacity Factor which automatically oversizes the activated sludge plant by the equation:

$$(ECF)t = 1.3 - 0.002\ Q_{AVG}.$$

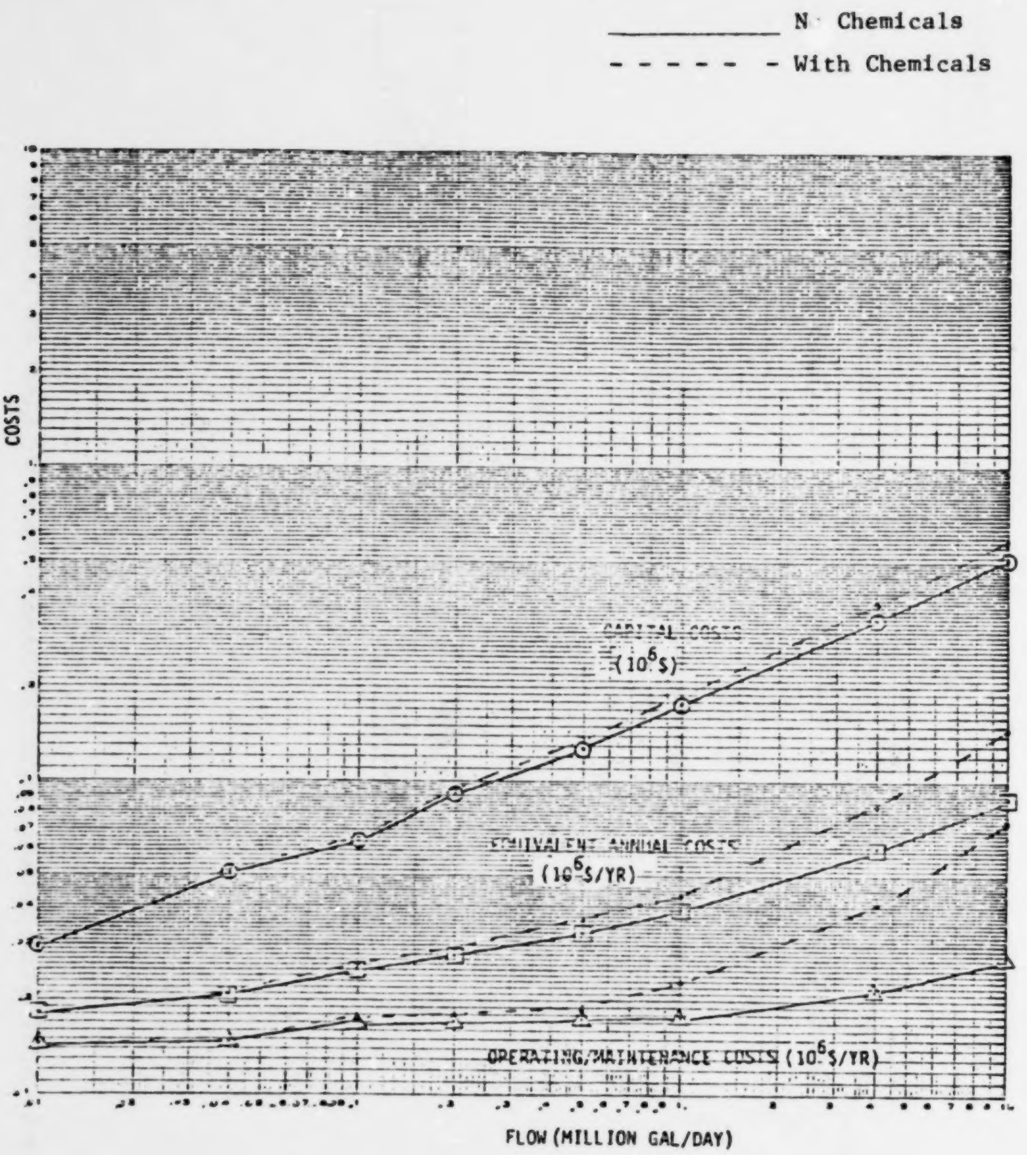

FIGURE 8-3 - CAPITAL, OPERATING AND ANNUAL COSTS, SEDIMENTATION

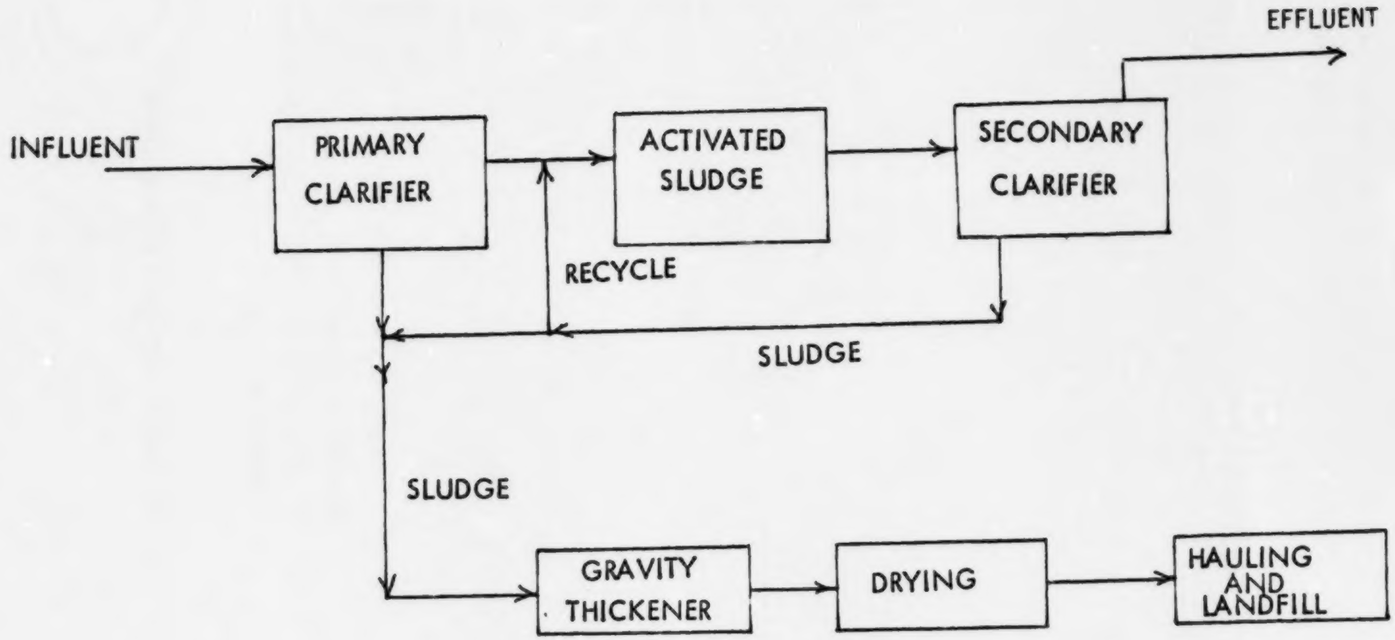
EFFLUENT
INFLUENT
PRIMARY CLARIFIER
ACTIVATED SLUDGE
SECONDARY CLARIFIER
RECYCLE
SLUDGE
SLUDGE
GRAVITY THICKENER
DRYING
HAULING AND LANDFILL

FIGURE 8-4 - ACTIVATED SLUDGE PROCESS CONSIDERED FOR COST ESTIMATION

Where:

(ECF)t = excess capacity factor for tank volume of aerator

Q_{AVG} = average daily wastewater flow MGD

(ECF)t is never less than 1.1

In similar calculations other components of the system also have excess capacity built in to calculations to accommodate peak demands and emergencies. Thus, without the rigorous variability analysis of the parameters, it is judged that peak demands are adequately addressed by the Excess Capacity Factor term in the model.

CAPDET predicts costs for BOD effluent levels less than 10 mg/l (LTM). However, considering the complex nature of industrial waste water and the relative accuracy of the test for BOD (±15 percent), it is reasonable to limit the general use of these costs to a minimum effluent target of 10 mg/l.

Several sample sets of curves are presented in Figures 8-5 through 8-7. Each set of curves lists capital, operating, or annual costs for a variety of effluent BOD concentrations and a fixed influent concentration. An example cost summary sheet used to plot one set of data points is presented in Table 8-6.

Aerated Lagoons

Aerated lagoons can provide a cost effective alternative to activated sludge treatment where sufficient land area is available. Because aerated lagoons utilize much longer detention times with lower biological solids concentrations they are less sensitive to variations in organic loading and flow.

The aerated lagoon system can approach or equal the organic removal capability of an activated sludge process, provided the unit is properly designed and operated. As indicated in Section VII, 26 plants in the Summary Data Base report using aerated lagoons as the major wastewater treatment process. Median effluent BOD and TSS for these plants are 15 mg/l and 33 mg/l, respectively.

Figure 8-8 shows the aerated lagoon system process diagram used for cost estimation. Table 8-7 shows a sample cost summary sheet, and Figures 8-9 through 8-11 graphically present a set of capital, operating and equivalent annual cost curves for aerated lagoons.

Multimedia Filtration

Removing finely divided suspended materials from wastewater (effluent polishing) is a growing technology of modern wastewater treatment. Two common methods are multimedia filtration and microstraining.[8-4] The design of filters depends on influent wastewater characteristics, process hydraulic loadings, method and intensity of cleaning; nature, size and depth of the filtering material, and the required quality of the

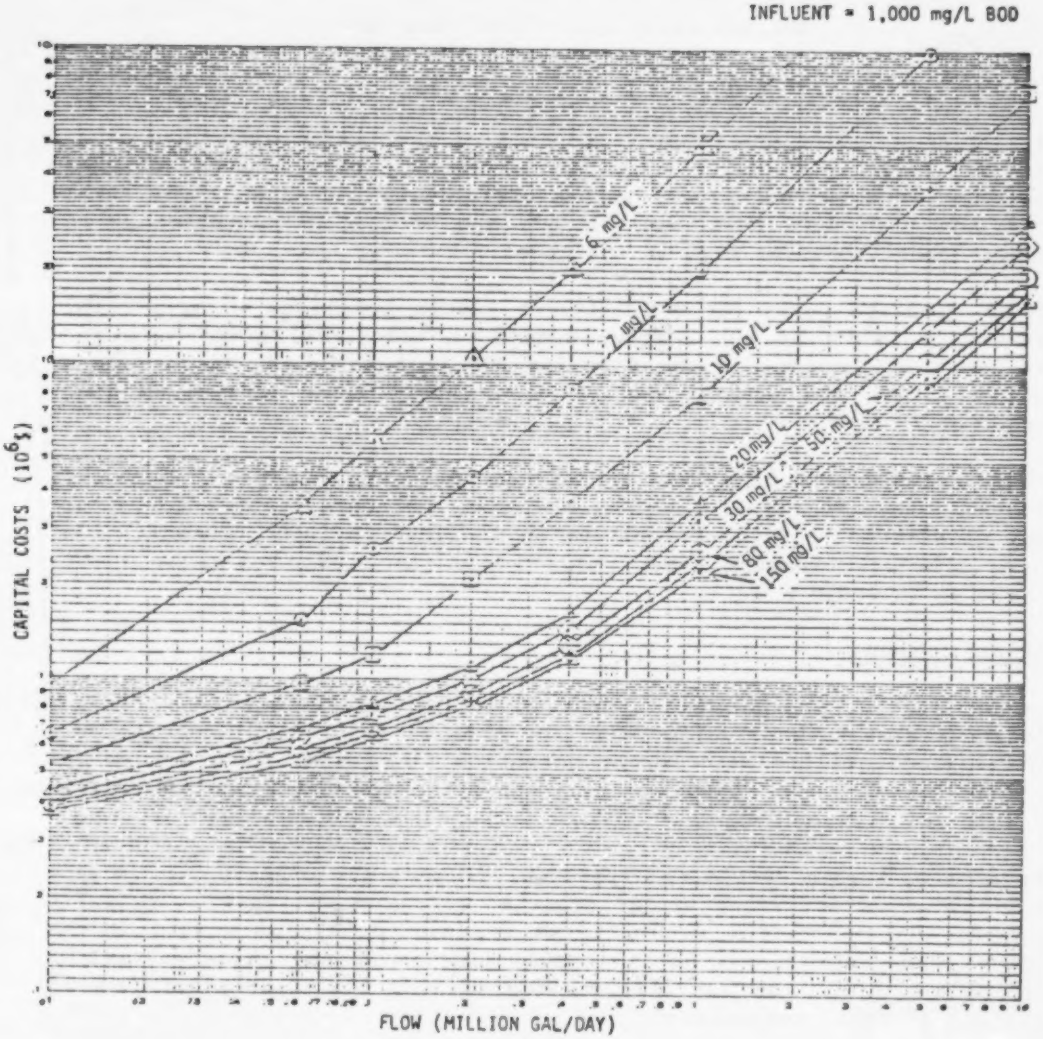

FIGURE 8-5–CAPITAL COSTS, ACTIVATED SLUDGE (1,000 mg/l)

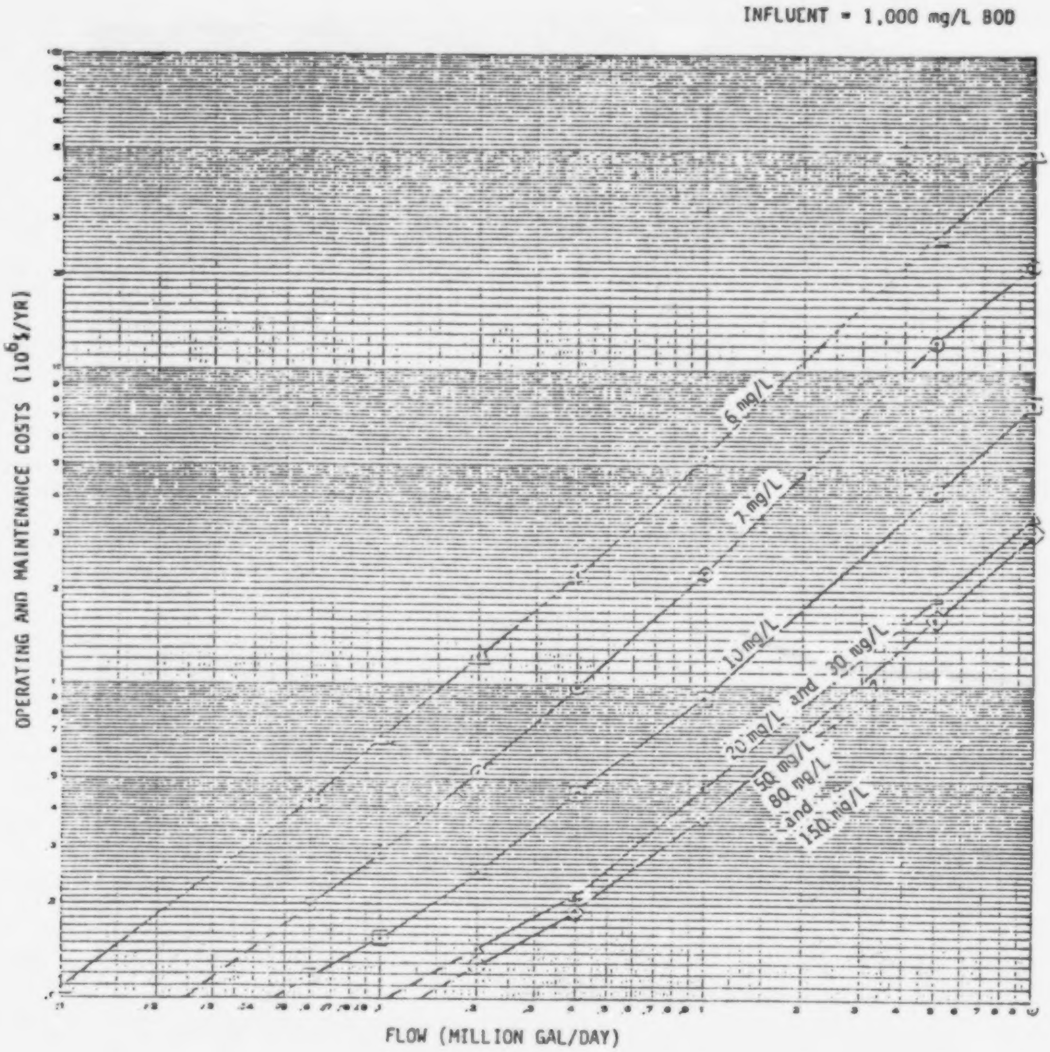

FIGURE 8-6—OPERATING COSTS, ACTIVATED SLUDGE (1,000 mg/l)

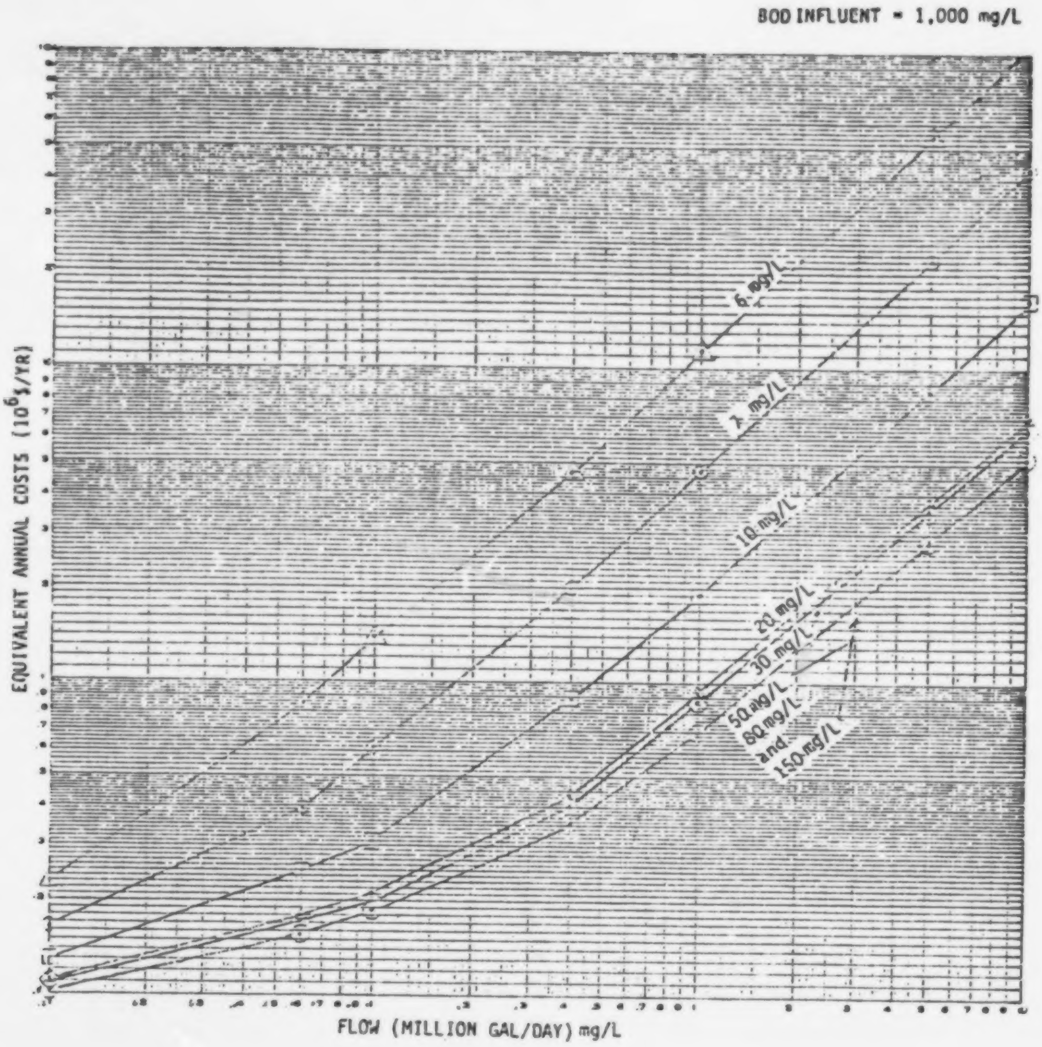

FIGURE 8-7–ANNUAL COSTS, ACTIVATED SLUDGE (1,000 mg/l)

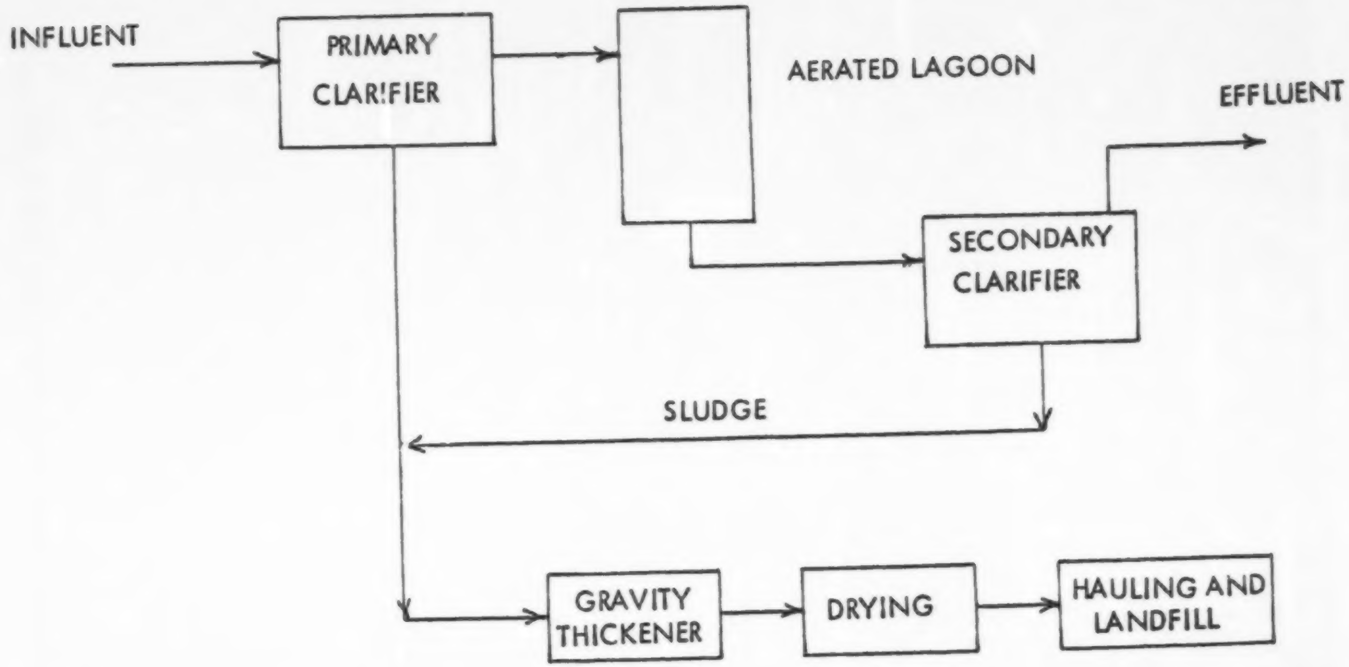
INFLUENT
PRIMARY CLARIFIER
AERATED LAGOON
EFFLUENT
SECONDARY CLARIFIER
SLUDGE
GRAVITY THICKENER
DRYING
HAULING AND LANDFILL

FIGURE 8-8 - AERATED LAGOON PROCESS CONSIDERED FOR COST ESTIMATION

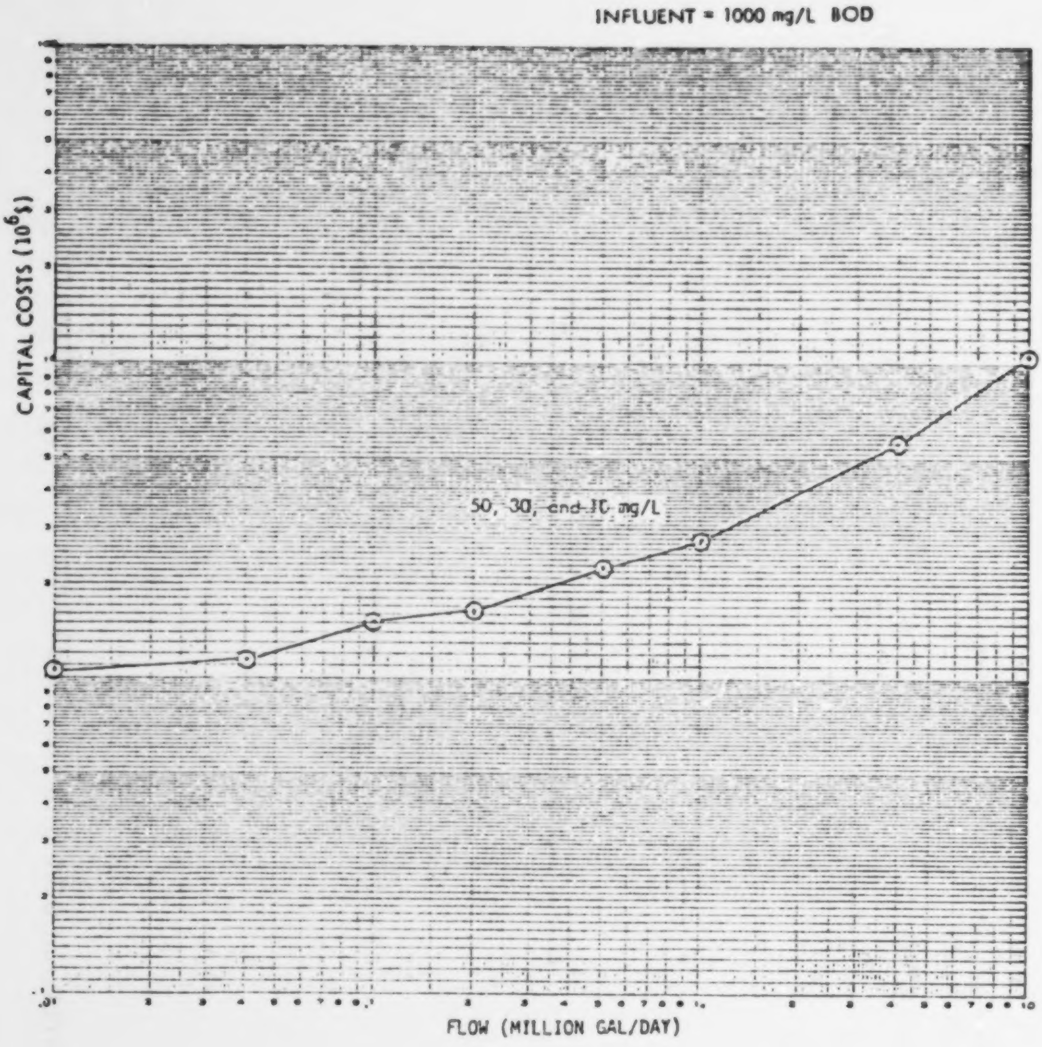

FIGURE 8-9–CAPITAL COSTS, AERATED LAGOONS (1,000 mg/l)

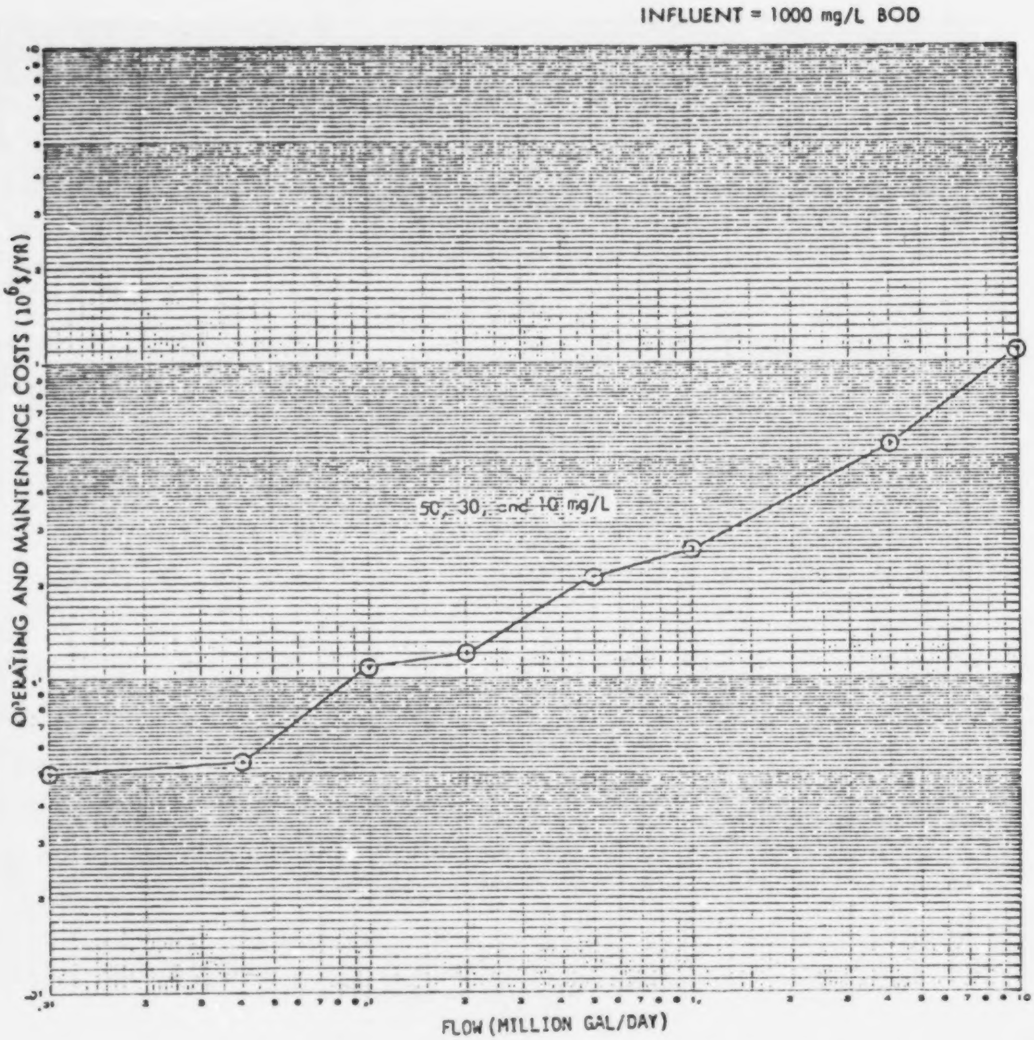

FIGURE 8-10 - OPERATING COSTS, AERATED LAGOONS (1,000 mg/l)

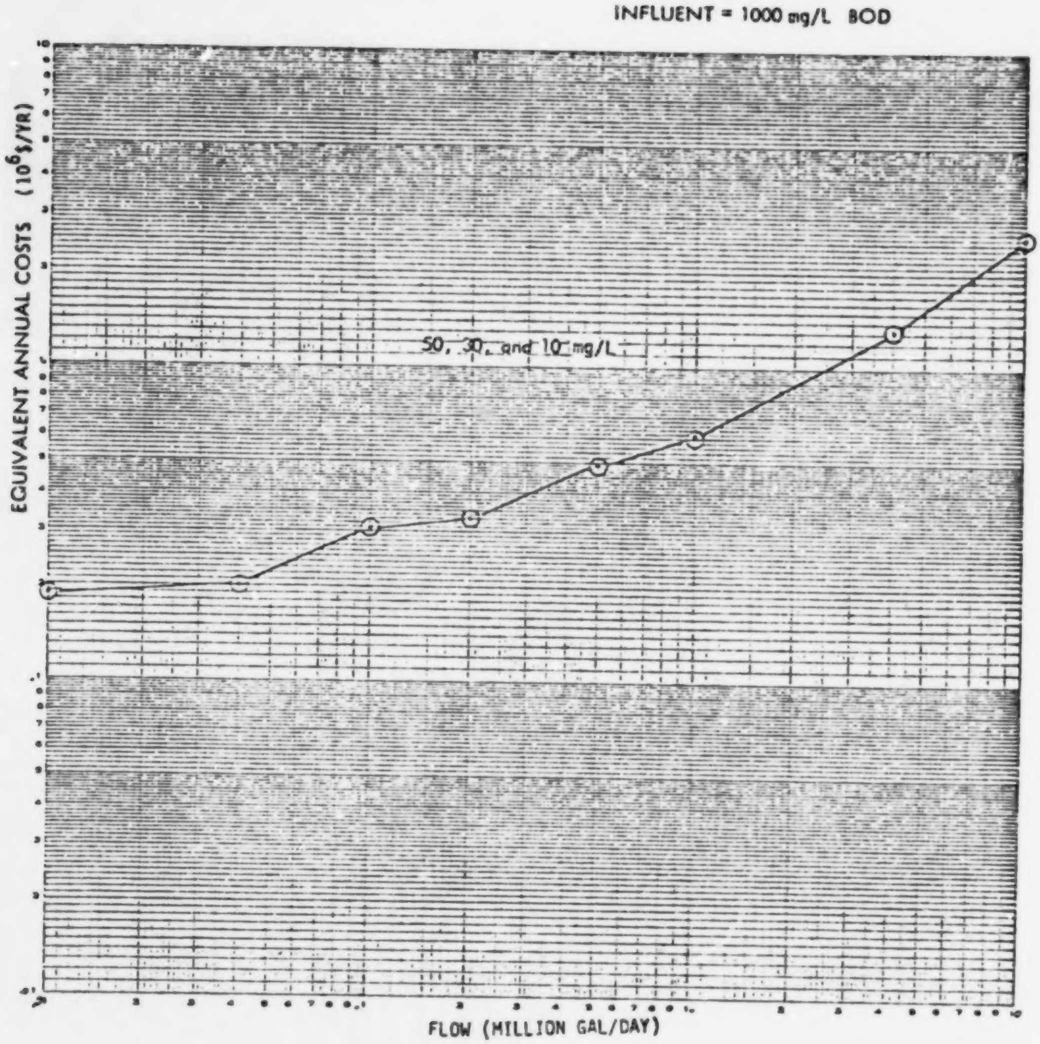

FIGURE 8-11–ANNUAL COSTS, AERATED LAGOONS (1,000 mg/l)

final effluent. However, the costs of filtration are primarily dependent on flow rate. In general, multimedia filters are more effective than most filters and are easier and less expensive to operate for the treatment of wastewaters. Typically, either multimedia or dual-media filtration will reduce suspended solids to about 5 to 19 mg/l (LTM). Multimedia filtration has been shown to reduce TSS levels by 55 to 99 percent in various cases.[8-5] In addition to suspended solids removal, resulting incidental BOD removals ranging from 40 to 90 percent have been accomplished using multimedia filtration.[8-5]

The design considered for cost estimation of multimedia filtration includes a layered filter with anthracite, sand, garnet sand and gravel. Pumps are used to provide pressure backwash. Surge tanks are provided to control the return of waste filter backwash water to treatment units. Surface sprayers and air blowers are included (see Figure 8-12).

Table 8-8 lists a sample cost summary sheet. The capital, operating and annual costs are plotted versus flow in Figure 8-13.

Polishing Ponds

Where sufficient land is available, polishing ponds may present an economically attractive alternative to multimedia filtration or microscreening as a means of reducing effluent TSS. It was determined that CAPDET could not be conveniently used to estimate polishing pond costs. Therefore, a manual estimating procedure similar to that used by CAPDET was used to determine the cost of applying polishing pond technology to four OCPS plants. The four plants which were selected represented a wide range of flow conditions. In addition, the four selected plants included one from each of the four proposed subcategories. Table 8-10 presents a cost summary for the application of polishing ponds at each of the four plants. Table 8-11 shows a comparison of the capital, operating and annual costs for polishing ponds with those costs generated by CAPDET for multimedia filtration. As indicated in the table, polishing pond costs are significantly lower. There are some minor differences in the cost estimating methods used, for example, polishing pond estimates do not include laboratory, administrative or inspection costs. These costs are, however, not significant in relation to the total cost of applying the technology. Inclusion of these additional cost items will still result in polishing pond technology being more cost effective than either multimedia filtration or microscreening.

Multimedia filtration, although more costly, is a more universally applicable technology. The significantly smaller land requirement may make filtration more attractive to plants where space is limited.

Since polishing ponds may not represent an implementable option at all OCPS manufacturing plants, multimedia filtration was used in preparing the plant-by-plant cost estimates. As indicated in Table 8-11, this represents a very conservative engineering approach in developing industry costs. Therefore, many of the OCPS industry plants will be able to provide solids control at a lower cost than that reflected by the plant-by-plant cost estimates.

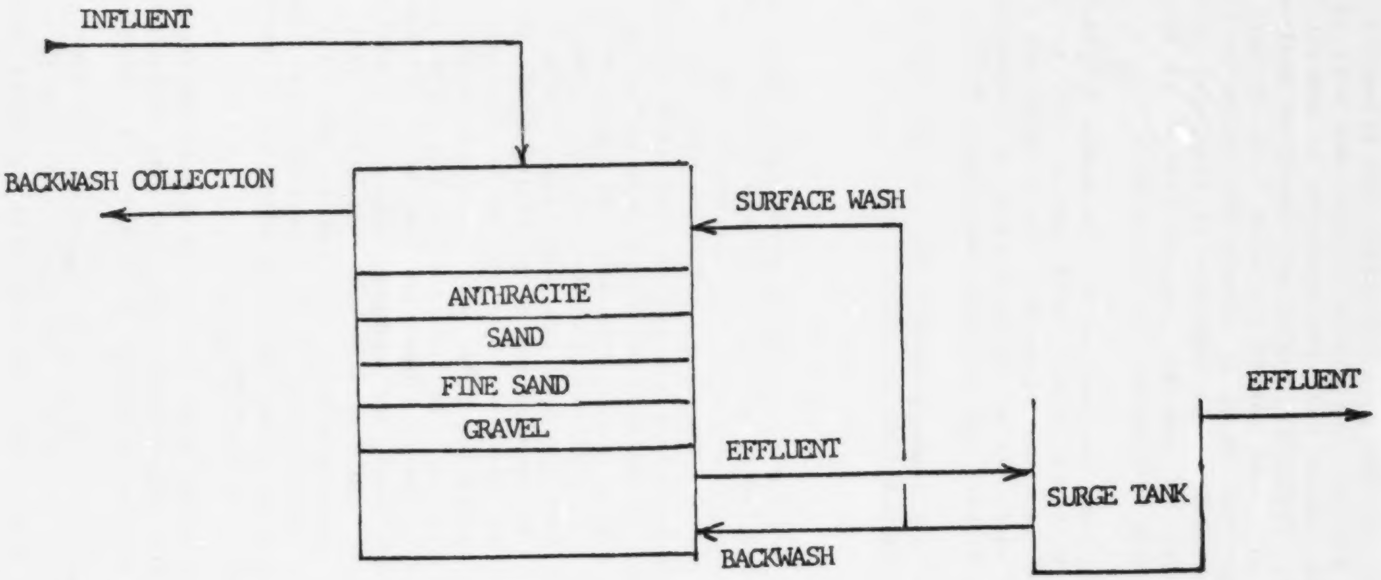
INFLUENT
BACKWASH COLLECTION
SURFACE WASH
ANTHRACITE
SAND
FINE SAND
GRAVEL
EFFLUENT
BACKWASH
SURGE TANK
EFFLUENT

FIGURE 8-12 - MULTIMEDIA FILTRATION PROCESS

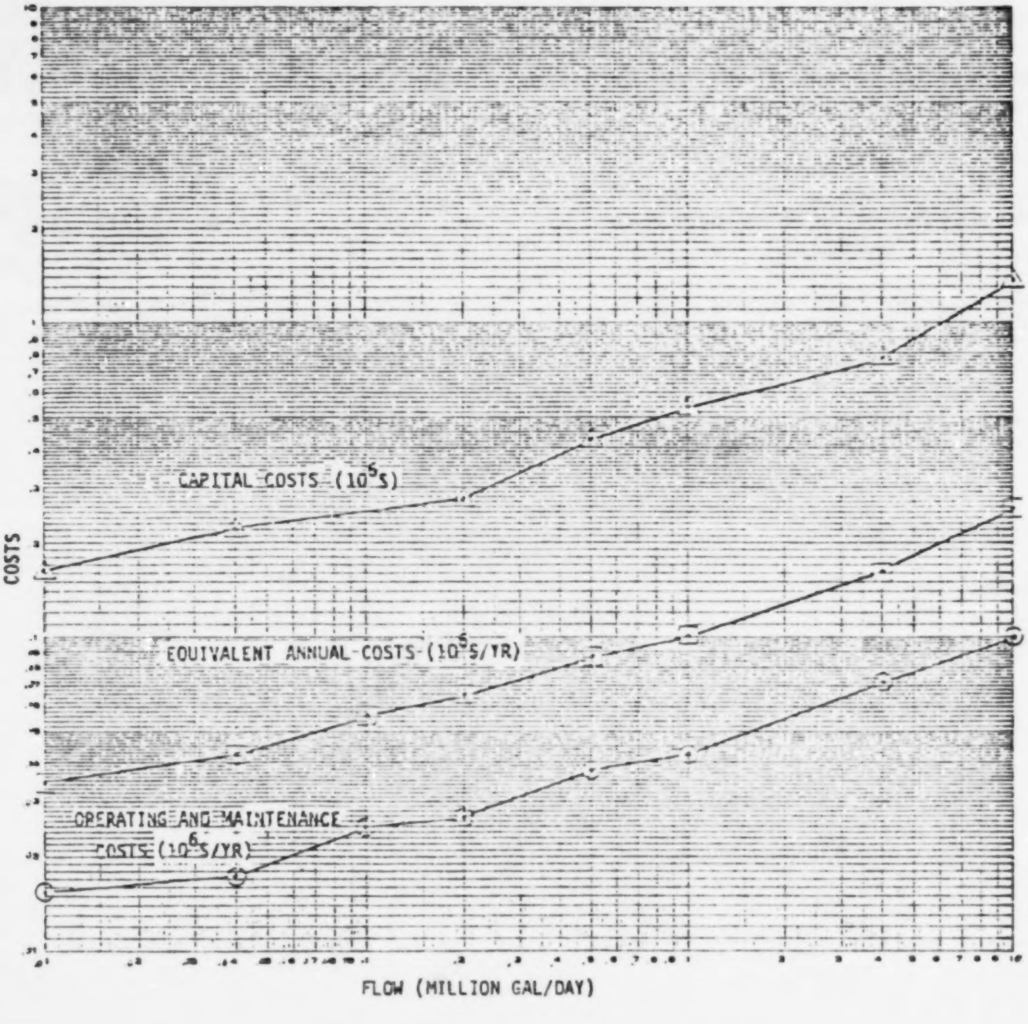

FIGURE 8-13 - CAPITAL, OPERATING AND ANNUAL COSTS, MULTIMEDIA FILTRATION

TABLE 8-10

COST SUMMARY, POLISHING PONDS

Plant: 9
Flow: 0.7 MGD
Subcategory: PLASTICS

Item	Unit Cost	Amount	Total Cost($)
Excavation (3,000 min)	1.20 $/yd^3	346 yd^3	3,000
Earth Prep (3,000 min)			3,000
Liner	0.54 $/ft^2	3900 ft^2	2,100
Subtotal			8,100
Miscellaneous (15% of subtotal)			1,215
Subtotal			9,315
Engineering (15%)(5,000 min)			5,000
Contingencies (15%)			1,400
Total Installed Cost			15,715
Land (2X pond)	10,000$/acre	0.18 acre	1,800
TOTAL CAPITAL COST			17,515
Operating Cost			
Maintenance (10%)			1,750
Sludge Disposal	7,600 $/yr MGD		530
Total Operating Cost			2,280
TOTAL ANNUAL COST 12.5% T.C.C. & T.O.C.			4,470

TABLE 8-10 (Continued)

COST SUMMARY, POLISHING PONDS

Plant: 97
Flow: 0.86 MGD
Subcategory: NOT PLASTICS/NOT TYPE I

Item	Unit Cost	Amount	Total Cost($)
Excavation	$1.20\ \$/\mathrm{yd}^3$	$4258\ \mathrm{yd}^3$	5,100
Earth Prep			5,100
Liner	$0.54\ \$/\mathrm{ft}^2$	$34225\ \mathrm{ft}^2$	18,480
Subtotal			28,680
Miscellaneous (15% of subtotal)			4,300
Subtotal			32,980
Engineering (15%)(5,000 min)			5,000
Contingencies (15%)			4,950
Total Installed Cost			42,930
Land (2X pond)	10,000$/acre	1.6 acre	16,000
TOTAL CAPITAL COST			58,930
Operating Cost			
Maintenance (10%)			5,900
Sludge Disposal	7,600 $/yr MGD		6,540
Total Operating Cost			12,440
TOTAL ANNUAL COST 12.5% T.C.C. & T.O.C.			19,800

TABLE 8-10 (Continued)

COST SUMMARY, POLISHING PONDS

Plant: 171
Flow: 1.44 MGD
Subcategory: NOT PLASTICS/TYPE I W/O OXIDATION

Item	Unit Cost	Amount	Total Cost($)
Excavation	1.20 $/yd^3	7130 yd^3	8,560
Earth Prep			8,560
Liner	0.54 $/ft^2	55225 ft^2	29,820
Subtotal			46,940
Miscellaneous (15% of subtotal)			7,040
Subtotal			53,980
Engineering (15%)(5,000 min)			8,100
Contingencies (15%)			8,100
Total Installed Cost			70,180
Land (2X pond)	10,000$/acre	2.6 acre	26,000
TOTAL CAPITAL COST			96,180
Operating Cost			
Maintenance (10%)			9,620
Sludge Disposal	7,600 $/yr MGD		10,940
Total Operating Cost			20,560
TOTAL ANNUAL COST 12.5% T.C.C. & T.O.C.			32,600

TABLE 8-10 (Continued)

COST SUMMARY, POLISHING PONDS

Plant: 60
Flow: 5.07 MGD
Subcategory: NOT PLASTICS/TYPE I WITH OXIDATION

Item	Unit Cost	Amount	Total Cost($)
Excavation	1.20 $/yd^3	25100 yd^3	30,120
Earth Prep			30,120
Liner	0.54 $/ft^2	180625 ft^2	97,540
Subtotal			157,780
Miscellaneous (15% of subtotal)			23,670
Subtotal			181,450
Engineering (15%)(5,000 min)			27,200
Contingencies (15%)			27,200
Total Installed Cost			235,850
Land (2X pond)	10,000$/acre	8.4 acre	84,000
TOTAL CAPITAL COST			319,850

Operating Cost

Item	Unit Cost	Amount	Total Cost($)
Maintenance (10%)			31,985
Sludge Disposal	7,600 $/yr MGD		38,530
Total Operating Cost			70,515
TOTAL ANNUAL COST 12.5% T.C.C. & T.O.C.			110,500

TABLE 8-11

COMPARISON OF POLISHING POND AND MULTIMEDIA FILTER COSTS

MULTIMEDIA FILTRATION

Plant	Capital Cost	Operating Cost	Annual Cost
9	240,000	22,000	52,000
60	900,000	80,000	190,000
97	520,000	42,000	100,000
171	600,000	50,000	120,000

POLISHING PONDS

Plant	Capital Cost	Operating Cost	Annual Cost
9	17,515	2,280	4,470
60	319,850	70,515	110,500
97	58,930	12,440	19,800
171	96,180	20,560	32,600

BENCH MARK ANALYSIS

A bench mark analysis was performed to compare the wastewater treatment technology cost estimates generated by CAPDET to actual industry experience. The objective of such an analysis is to determine the reasonableness of relying on the modified CAPDET costing model to estimate OCPS industry wastewater treatment costs.

Appropriate cost data were available from a total of four facilities, three from the organic chemicals and plastics and synthetics resins industry, and one from the petroleum refining industry. The data tabulated from these facilities, shown in Table 8-12, were selected because of their similarity to treatment system configurations utilized in the CAPDET estimates.

In all cases the costs were adjusted to the same cost year dollars to avoid distortions caused by changes in the construction cost index.

Although there are differences in the cost comparisons between the CAPDET plants and the industry plants, there is no definitive pattern to the differences in either magnitude or direction.

It is judged that cost differences may be due to variations in the cost accounting and cost estimating procedures which vary from one company to another.

In reference to the capital cost differences, the variations between the CAPDET estimates and the industry actuals are within the range normally associated in industrial practice with the preliminary engineering cost (±30%). To obtain more precise values requires substantially more detailed information than is available from the industrial costs studied.

It is therefore judged that CAPDET is a useful model with sufficient accuracy in cost estimating to permit an economic impact analysis to be made, providing that the industrial factors are used in the model as required.

EFFLUENT TARGET LEVELS

During the initial phases of the regulatory development, a series of effluent target levels for the OCPS industries were defined based on the performances demonstrated by the plants represented in the data base. Targets were selected to range from the minimum treatment level judged necessary to avoid serious potential adverse impacts on receiving waters, to the maximum degree of treatment shown to be achievable by well designed and operated plants within the industry group.

The least stringent BOD target concentration has been defined as 50 mg/l (LTM). Of the direct discharge plants in the data base, 74 percent have effluent BOD concentrations equal to or less than this value. For Plastics Only plants the most stringent target considered for BOD is 10 mg/l (LTM). This corresponds to an effluent BOD concentration slightly below the median obtained for well run Plastics Only plants (see Table 7-27). For Not Plastics Plants, the lowest effluent BOD target has been

TABLE 8-12-BENCH MARK COMPARISONS

Plant No., Treatment Type, and Design Parameters		Reported Costs	CAPDET Costs	Difference (CAPDET - Reported)	% Difference Compared to Reported Cost
					CAPDET IS
#146					
ASL @ 0.8 MGD	Capital,$	2,421,000	2,300,000	-121,000	5% low
BOD INF 720 mg/l	Operating,$/YR	376,800	310,000	- 66,800	18% low
BOD EFF 20 mg/l	Eq. Annual,$/YR	661,600	580,000	- 81,600	12% low
#42					
ASL @ 0.13 MGD	Capital,$	1,082,000	900,000	-182,000	17% low
BOD INF 6,000 mg/l	Operating,$/YR	190,000	140,000	- 50,000	26% low
BOD EFF 380 mg/l	Eq. Annual,$/YR	317,000	260,000	- 57,000	18% low
#178					
ASL @ 3.5 MGD	Capital,$	7,960,000	8,000,000	+ 40,000	0.5% high
BOD INF 1,000 mg/l	Operating,$/YR	837,000	1,200,000	+363,000	43% high
BOD EFF 50 mg/l	Eq. Annual,$/YR	1,778,000	2,140,000	+362,000	20% high
Petroleum Refinery ASL @ 2.2 MGD BOD INF 134 mg/l BOD EFF 12 mg/l	Installed Equipment Costs Only, $	630,000	868,000	+238,000	38% high
CLAR @ 2.2 MGD	Installed Equipment Costs Only, $	190,000	155,000	- 35,000	18% low
DAF without Chemical Feed @ 2.2 MGD	Installed Equipment Costs Only, $	155,000	205,000	+ 50,000	32% high

defined as 15 mg/l (LTM). This represents the median value obtained by the "Not Type I" segment of the Not Plastics Plants.

Three suspended solids targets were evaluated for engineering cost estimations. The highest effluent TSS target considered was 50 mg/l (LTM), which represents the level generally achievable using conventional clarification. Sixty-six percent of direct dischargers in the data base reported effluent TSS concentrations equal to or less than this value. The minimum target concentration considered is 20 mg/l (LTM), which is judged to be attainable using multimedia filtration or microscreening technology.

Based on these considerations, a series of target concentrations for BOD and TSS were defined. These targets, and the plants to which they are applied are presented in Table 8-13.

TABLE 8-13

EFFLUENT TARGET LEVELS

Target Level	(BOD/TSS)mg/l	Applied to
I	(50/50)	All Plants
II	(30/30)	All Plants
III	(20/20)	All Plants
IVa	(10/20)	Plastics Plants
IVb	(15/20)	Not Plastics Plants

For the plant-by-plant analysis, a tabulation of costs was prepared for each plant listing the treatment technology alternatives and corresponding estimated costs required to meet the four proposed effluent target levels for BOD and TSS. An example cost summary sheet for achieving Targets I, II and III for plant 203 is presented in Table 8-14. This example provides a reference for the following discussion.

The treatment alternatives considered for this plant-by-plant analysis include clarification, dissolved air flotation, activated sludge, aerated lagoons and multimedia filtration.

Based on an anlysis of the data available for engineering cost analysis, there are plants that will require (a) biological treatment for the removal of BOD and/or TSS, and/or (b) solids removal treatment for the reduction of TSS and/or BOD levels, or (c) no further treatment.

To achieve further BOD removal, the following criteria based on the generally attainable treatment levels (see Section VII) are established for the plant-by-plant analysis:

1. For plants with BOD concentrations greater than the targets and with reported solids less than the targets, biological systems are required except in the case of Criterion 3.

TABLE 8-14 SAMPLE PLANT-BY-PLANT COST ANALYSIS

PLANT BY PLANT COST ANALYSIS

REPORTED WASTEWATER DATA

Plant Number: 203 Flow (Million GPD): 0.106 BOD Effluent (mg/l): 181 TSS Effluent (mg/l): 147 Reported Treatment: ASL

ALTERNATIVE UPGRADE COSTS

Proposed Effluent Target I

Biological	BOD/TSS Attainable	Capital Cost ($)	Operating Cost ($/yr)	Annual Cost ($/yr)	Solids	BOD/TSS = (50/50) TSS Attainable	Capital Cost ($)	Operating Cost ($/yr)	Annual Cost ($/yr)	Suggested Total Plant Treatment	Capital Cost ($)	Operating Cost ($/Yr)	Annual Cost ($/Yr)
1. ASL	(50/50)	510,000	50,000	130,000	1. CLAR	(50)	64,000	12,000	25,000	1. ASL	510,000	50,000	130,000
2. ALA	(50/100)	1,400,000	100,000	300,000	2. DAF	(50)	75,000	14,000	23,000	2. ALA/CLAR	1,473,000	111,000	323,000
					3. MMF	(20)	250,000	25,000	51,000				

Proposed Effluent Target II

Biological	BOD/TSS Attainable	Capital Cost ($)	Operating Cost ($/yr)	Annual Cost ($/yr)	Solids	BOD/TSS = (30/30) TSS Attainable	Capital Cost ($)	Operating Cost ($/yr)	Annual Cost ($/yr)	Suggested Total Plant Treatment	Capital Cost ($)	Operating Cost ($/Yr)	Annual Cost ($/Yr)
1. ASL	(30/30)	510,000	50,000	130,000	1. MMF	(20)	250,000	25,000	51,000	1. ASL/MMF	760,000	75,000	181,000
2. ALA	(30/100)	1,400,000	100,000	300,000	2. MICRO	(20)	250,000	25,000	51,000	2. ALA/MMF	1,650,000	125,000	351,000

Proposed Effluent Target III

Biological	BOD/TSS Attainable	Capital Cost ($)	Operating Cost ($/yr)	Annual Cost ($/yr)	Solids	BOD/TSS = (20/20) TSS Attainable	Capital Cost ($)	Operating Cost ($/yr)	Annual Cost ($/yr)	Suggested Total Plant Treatment	Capital Cost ($)	Operating Cost ($/Yr)	Annual Cost ($/Yr)
1. ASL	(20/30)	510,000	54,000	140,000	1. MMF	(20)	250,000	25,000	57,000	[✓ 1. ASL/MMF]	760,000	79,000	197,000
2. ALA	(20/100)	1,400,000	100,000	300,000	2. MICRO	(20)	250,000	25,000	57,000	2. ALA/MMF	1,650,000	125,000	357,000

REMARKS:

Target IV (15/20) same as Target III

2. For plants with BOD concentrations greater than the targets (but not exceeding the targets by an amount equal to 60 percent of the target concentration) and with TSS concentrations greater than the targets, BOD reduction can be achieved with solids removal.

3. For plants with BOD concentrations within the 60 percent range of targets specified in Criterion 2 and with TSS concentrations less than the targets, BOD reduction by solids removal may be achieved if the amount of BOD to be removed is less than or equal to 75 percent of the TSS available for removal. This assumes 75 percent of the solids removed are biological and thus contribute to effluent BOD. Multimedia filters have been shown to reach effluent solids concentration of 5 to 19 mg/l (LTM).

4. For plants requiring the addition of biological systems, the solids leaving the proposed secondary clarifiers are assumed to meet the TSS Target of 50 mg/l for activated sludge systems. However, for aerated lagoons some form of secondary solids separation will be required to achieve the 50 mg/l TSS Target. Additional solids treatment beyond conventional secondary clarification is required for all biological systems to achieve Targets II and III. The exception to this rule includes cases where a biological system is added to a reported biological system of the same type which produce solids concentrations that meet the proposed targets. For example, an activated sludge system added to a reported activated sludge system with excessive BOD and sufficiently low TSS is assumed to produce solids with similar settling characteristics and equivalent effluent TSS levels.

5. For each target, three biological alternatives are presented for the cases requiring BOD reduction by means of biological treatment. If solids removal alternatives are also presented, there are several possible combinations of bio-solid treatment alternatives. For example, an aerated lagooon system may be combined with additional clarification, dissolved air flotation, or multimedia filtration. There is no specific combination intended by placement of biological and solids alternatives on the same line of the cost sheet for each plant.

To achieve further TSS removal the following criteria are established:

1. For plants with TSS concentrations greater than the targets and also requiring biological treatment, the achievable TSS effluent concentrations are determined by the biological system (activated sludge: 50 mg/l (LTM), aerated lagoon: 100 mg/l (LTM). For Target I, additional solids removal alternatives are required for aerated lagoons, but not for activated sludge systems. Additional solids removal alternatives are required for all biological systems for Targets II and III except as noted. Clarification and dissolved air flotation are suitable alter-

natives to achieve Target I, but for Targets II and III, multimedia filtration or microscreening is necessary.

2. For plants with TSS concentrations above the proposed target levels and without additional biological system requirements, further solids removal can be achieved to reach Target I by clarification or dissolved air flotation, or for Targets II and III by multimedia filtration or microscreening.

3. For plants with TSS concentrations exceeding 200 mg/l (LTM), clarification or dissolved air flotation should precede multimedia filtration (or microscreening).

4. For plants with insufficient TSS data, but sufficient BOD data, costs based on a few additional assumptions are provided. The costs for plants with high BOD levels are not affected since the solids effluent is based on the biological treatment chosen. For plants with BOD levels within 60 percent of the proposed target, it is assumed that BOD reduction via solids removal is appropriate. This type case exists frequently among plants with sufficient BOD and TSS data. For plants meeting BOD targets, solids targets are assumed also to be within the target limits. These assumptions are considered reasonable based on the cases existing in the plants with sufficient data.

There are five plants with flows greater than 10 MGD (the maximum flow on the cost curves) and with concentrations above the targets. The flow rates are 10.7, 15.8, 16.7, 19.9, and 40 MGD. Costs for these plants were obtained from the graphs through a simple extrapolation of the curve.

The accuracy of the extension for the plant with a flow of 40 MGD is questionable; however, the only costs for this plant are for the installation of multimedia filtration. The modular nature of filtration systems suggests that simple extrapolation of costs will tend to overestimate rather than underestimate the cost of the system. In any case, the possible error which could result from this approach is small in relation to the total estimated cost for that portion of the industry requiring additional treatment.

The treatment codes used in the plant-by-plant analysis, as illustrated in Table 8-14, are defined as follows:

1. ASL refers to activated sludge
2. ALA refers to aerated lagoons
3. CLAR refers to clarification
4. DAF refers to dissolved air flotation
5. MMF refers to multimedia filtration
6. MICRO refers to microscreening

For plants with multiple streams, the costs are reviewed for treating each stream both individually and mixed. The least annual cost is considered the suggested alternative for each target. It is assumed for estimating purposes that mixing is a viable alternative even though mixing possibly would be difficult for some plants (e.g., a plant where inadequate piping between streams exists).

PLANT-BY-PLANT COST RESULTS

Costs for the preliminary plant-by-plant analysis are summarized in Table 8-15 and 8-16.

A review of the total costs indicates that for a 170 plant data base, the annual costs are $10,346,000 per year for Target I, $21,887,000 per year for Target II, $28,963,000 per year for Target III and $33,131,000 per year for Target IV.

BPT COST ESTIMATES

A second group of plant-by-plant cost estimates were prepared to determine the cost of complying with two sets of effluent limitations which could potentially be applied to the OCPS industry. These targets, identified as BPT (I) and BPT (II), have been developed separately for each proposed subcategory. Limitations are based on the effluent concentrations achieved by well designed and operated plants in the Summary Data Base. A more detailed explanation of the rationale for these potential limitations is presented in Sections IX and X.

The proposed effluent limitations used to develop these cost estimates are shown in Table 8-17. As the table indicates, the BPT (I) and BPT (II) differ in the level of effluent TSS control required. The costing methodology used for preparing the cost estimates was identical to that used earlier (see pages 235 thru 240). As previously explained, multimedia filters were costed as the technology used for effluent solids control. Use of polishing ponds, although not applicable to every OCPS plant, would result in significantly lower costs.

The plant-by-plant cost analysis to achieve BPT (I) and BPT (II) is presented in Table 8-18. Plant-by-plant costs are listed by subcategory.

Table 8-19 presents a summary of the total costs for additional treatment to meet the two sets of potential guidelines. Plant costs are presented by subcategory.

Table 8-20 indicates the percentage of plants in the Summary Data Base which require additional treatment to achieve BPT (I) limits. Table 8-21 presents the same information for BPT (II).

Table 8-22 presents the percentage of annual costs by subcategory to meet BPT (I) and BPT (II). Also shown for each target is the percentage of the total etimated annual cost attributable to each subcategory.

It should be noted that the plant counts in the earlier cost estimates do not agree with counts in the "BPT" costing exercise. This is due to the following factors: (1) the project data base has been updated since the earlier efforts, changing the count of direct dischargers, and (2) when the plants were re-subcategorized into 5 subcategories streams from multi-stream plants were evaluated differently.

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TABLE 8-15 PLANT-BY-PLANT SUGGESTED TREATMENTS AND COSTS, NON-PLASTICS

Plant No.	TARGET I (50/50) Suggested Treatment	TARGET I (50/50) Capital Costs ($)	TARGET I (50/50) Operating Costs ($/yr)	TARGET I (50/50) Annual Costs ($/yr)	TARGET II (30/30) Suggested Treatment	TARGET II (30/30) Capital Costs ($)	TARGET II (30/30) Operating Costs ($/yr)	TARGET II (30/30) Annual Costs ($/yr)	TARGET III (20/20) Suggested Treatment	TARGET III (20/20) Capital Costs ($)	TARGET III (20/20) Operating Costs ($/yr)	TARGET III (20/20) Annual Costs ($/yr)
1	CLAR	145,000	18,000	38,000	MMF	470,000	40,000	95,000	MMF	470,000	40,000	95,000
18	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	825,000	75,000	170,000
16	ALA/CLAR	5,530,000	495,000	1,200,000	ALA/MMF	5,650,000	537,000	1,270,000	ALA/MMF	5,850,000	537,000	1,270,000
21	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
28	NO TREAT	0	0	0	NO TREAT	0	0	0	ASL/MMF	2,640,000	283,000	605,000
35	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
36	ASL	500,000	56,000	130,000	ASL/MMF	740,000	76,000	180,000	ASL/MMF	840,00	78,000	195,000
50	CLAR	100,000	17,000	29,000	MMF	320,000	30,000	72,000	MMF	320,000	30,000	72,000
52	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
53	CLAR	260,000	20,000	50,000	MMF	675,000	60,000	135,000	MMF	675,000	60,000	135,000
57	CLAR	290,000	21,000	55,000	MMF	720,000	65,000	150,000	MMF	720,000	65,000	150,000
59	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	600,000	50,000	120,000
60	CLAR	370,000	23,000	55,000	MMF	930,000	80,000	190,000	MMF	930,000	80,000	190,000
62	ASL	1,150,000	120,000	200,000	ASL/MMF	1,750,000	168,000	375,000	ASL/MMF	1,750,000	168,000	375,000
64	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
76	NO TREAT	0	0	0	MMF	2,600,000	165,000	490,000	MMF	2,800,000	165,000	490,000
80	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
85	CLAR	105,000	17,000	30,000	MMF	340,000	32,000	75,000	MMF	340,000	32,000	75,000
94	CLAR	1,500,000	45,000	250,000	MMF	5,000,000	250,000	850,000	MMF	5,000,000	250,000	850,000
97	CLAR	165,000	18,000	37,000	MMF	520,000	42,000	100,000	MMF	520,000	42,000	100,000
102	NO TREAT	0	0	0	MMF	700,000	62,000	140,000	MMF	700,000	62,000	140,000
110	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
112	MMF	500,000	41,000	97,000	ASL	930,000	95,000	210,000	ASL/MMF	1,430,000	136,000	307,000
113	NO TREAT	0	0	0	NO TREAT	0	0	0	ASL/MMF	7,300,000	780,000	1,550,000
114	CLAR	350,000	22,000	64,000	MMF	650,000	77,000	170,000	MMF	650,000	77,000	170,000
120	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	2,500,000	150,000	450,000
127	ASL	1,200,000	115,000	280,000	ASL/MMF	1,760,000	159,000	390,000	ASL/MMF	1,960,000	174,000	420,000

TARGET IV (15/20)

Plant #	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)
1	MMF	470,000	40,000	95,000
18	MMF	825,000	75,000	170,000
16	ALA/MMF	5,850,000	537,000	1,270,000
21	No Treat	0	0	0
28	ASL/MMF	2,640,000	283,000	605,000
35	No Treat	0	0	0
36	ASL/MMF	840,000	78,000	195,000
50	MMF	320,000	30,000	72,000
52	No Treat	0	0	0
53	MMF	675,000	60,000	135,000
57	MMF	720,000	65,000	150,000
59	MMF	600,000	50,000	120,000
60	MMF	900,000	80,000	190,000
62	ASL/MMF	1,750,000	168,000	375,000
64	No Treat	0	0	0
76	MMF	2,800,000	165,000	490,000
80	No Treat	0	0	0
85	MMF	340,000	32,000	75,000
94	MMF	5,000,000	250,000	850,000
97	MMF	520,000	42,000	100,000
102	MMF	700,000	62,000	140,000
110	No Treat	0	0	0
112	ASL/MMF	1,430,000	136,000	307,000
113	ASL/MMF	7,300,000	780,000	1,550,000
114	MMF	850,000	77,000	170,000
120	MMF	2,500,000	150,000	450,000
127	ASL/MMF	1,960,000	174,000	420,000

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TABLE 8-15 (cont), NON-PLASTICS

Plant No.	TARGET I (50/50)				TARGET II (30/30)				TARGET III (20/20)			
	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)
128	NO TREAT	0	0	0	MMP	650,000	88,000	150,000	MMF	850,000	88,000	150,000
130	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
138	ASL	800,00	105,000	230,000	ASL/MMF	1,220,000	141,000	315,000	ASL/MMF	1,445,000	151,000	335,000
144	NO TREAT	0	0	0	MMF	540,000	42,000	100,000	MMP	540,000	42,000	100,000
145	NO TREAT	0	0	0	MMP	600,000	50,000	120,000	MMP	600,000	50,000	120,000
160	ASL	780,000	80,000	175,000	ASL/MMF	1,180,000	118,000	260,000	ASL/MMP	1,180,000	118,000	260,000
171	NO TREAT	0	0	0	MMF	600,000	50,000	120,000	MMP	600,000	50,000	120,000
178	ASL	2,000,000	200,000	500,000	ASL/MMP	2,700,000	203,000	640,000	ASL/MMP	3,100,000	303,000	720,000
183	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
186	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
188	NO TREAT	0	0	0	MMF	540,000	42,000	100,000	MMF	540,000	42,000	103,000
216	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	350,000	24,000	55,000
218	ASL	380,000	43,000	102,000	ASL/MMF	565,000	60,000	141,000	ASL/MMF	565,000	60,000	141,000
219	CLAR	55,000	16,000	22,000	MMF	230,000	20,000	48,000	MMF	230,000	20,000	48,000
220	DAF	78,000	15,000	23,000	MMF	250,000	25,000	56,000	MMP	250,000	25,000	56,000
222	ASL	860,000	110,000	230,000	ASL/MMF	1,210,000	142,000	306,000	ASL/MMP	1,450,000	152,000	346,000
226	CLAR	190,000	18,000	41,000	MMF	560,000	40,000	110,000	MMF	560,000	45,000	110,000
228	CLAR	320,000	21,000	60,000	MMF	750,000	70,000	160,000	MMP	750,000	70,000	160,000
231	ASL	600,000	150,000	190,000	ASL/MMF	1,120,000	140,000	282,000	ASL/MMP	1,270,000	156,000	332,000
239	NO TREAT	0	0	0	MMF	165,000	16,000	35,000	MMP	165,000	16,000	35,000
247	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	725,000	65,000	150,000
256	NO TREAT	0	0	0	MMP	270,000	26,000	64,000	MMP	270,000	26,000	84,000
257	ASL	870,000	90,000	210,000	ASL/MMP	1,330,000	129,000	302,000	ASL/MMP	1,330,000	129,000	330,000
263	NO TREAT	0	0	0	MMP	205,000	17,000	41,000	ASL/MMP	605,000	57,000	148,000
264	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	630,000	53,000	130,000
270	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
271	CLAR	185,000	18,000	40,000	MMF	560,000	44,000	110,000	MMF	560,000	44,000	110,000

TARGET IV (15/20)

Plant #	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)
128	MMF	650,000	68,000	150,000
130	No Treat	0	0	0
138	ASL/MMF	1,445,000	151,000	335,000
144	MMF	540,000	42,000	100,000
145	MMF	600,000	50,000	120,000
160	ASL/MMF	1,180,000	118,000	260,000
171	MMF	600,000	50,000	120,000
178	ASL/MMF	3,100,000	303,000	720,000
183	No Treat	0	0	0
180	No Treat	0	0	0
188	MMF	540,000	42,000	100,000
216	MMF	250,000	24,000	55,000
218	ASL/MMMF	565,000	60,000	141,000
219	MMF	230,000	20,000	48,000
220	MMF	250,000	25,000	56,000
222	ASL/MMF	1,450,000	152,000	346,000
226	MMF	560,000	46,000	110,000
228	MMF	750,000	70,000	160,000
231	ASL/MMF	1,270,000	156,000	332,000
239	MMF	165,000	16,000	35,000
247	MMF	725,000	65,000	150,000
256	MMF	270,000	26,000	64,000
277	ASL/MMF	1,330,000	129,000	320,000
263	ASL/MMF	605,000	57,000	146,000
264	MMF	630,000	53,000	130,000
270	No Treat	0	0	0
271	MMF	560,000	44,000	110,000

TABLE 8-15 (cont), NON-PLASTICS

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	TARGET I (50/50)				TARGET II (30/30)				TARGET III (20/20)			
Plant No.	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)
269	CLAR	340,000	22,000	62,000	MMF	800,000	75,000	170,000	MMF	800,000	75,000	170,000
273	CLAR	340,000	22,000	62,000	MMF	800,000	75,000	170,000	MMF	800,000	75,000	170,000
275	ASL	540,000	58,000	135,000	ASL/MMF	800,000	84,000	185,000	ASL/MMF	800,000	84,000	195,000
* 15	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	670,000	60,000	135,000
* 20	ASL	480,000	48,000	130,000	ASL/MMF	720,000	70,000	170,000	ASL/MMF	740,000	74,000	180,000
* 42	ASL	490,000	54,000	125,000	ASL/MMF	720,000	73,000	170,000	ASL/MMF	810,000	75,000	185,000
* 81	ASL	1,550,000	170,000	350,000	ASL/MMF	2,220,000	230,000	495,000	ASL/MMF	2,220,000	230,000	495,000
* 84	CLAR	430,000	25,000	75,000	MMF	1,050,000	85,000	210,000	ASL/MMF	3,900,000	420,000	890,000
* 103	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
* 118	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
* 170	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	700,000	84,000	145,000
* 175	NO TREAT	0	0	0	MMF	520,000	44,000	98,000	MMF	520,000	44,000	98,000
* 177	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
* 234	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
TOTALS		23,773,000	2,226,000	5,158,000		47,287,000	4,185,000	10,018,000		70,015,000	8,386,000	14,879,000

*INSUFFICIENT TSS DATA.

TARGET IV (15/20)

Plant #	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)
269	MMF	800,000	75,000	170,000
272	MMF	800,000	75,000	170,000
275	ASL/MMF	800,000	84,000	195,000
15	MMF	670,000	60,000	135,000
20	AS1/MMF	740,000	74,000	180,000
42	ASL/MMF	810,000	75,000	185,000
61	ASL/MMF	2,220,000	230,000	495,000
84	ASL/MMF	3,900,000	420,000	890,000
103	No Treat	0	0	0
118	No Treat	0	0	0
170	MMF	700,000	84,000	145,000
175	MMF	520,000	44,000	98,000
177	No Treat	0	0	0
234	No Treat	0	0	0

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TABLE 8-15 (cont), NON-PLASTICS

Plant No.	TARGET I (50/50)				TARGET II (30/30)				TARGET III (20/20)			
	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)
	Mix Streams				Treat STM.1				Treat STM.1			
8	IIII: No.TRT	0	0	0	ASL/MMP	740,000	75,000	178,000	ASL/MMP	740,000	75,000	179,000
31	CLAR	185,000	18,000	40,000	MMP	550,000	44,000	108,000	MMP	550,000	44,000	108,000
32	ASL	410,000	44,000	106,000	ASL/MMP	620,000	61,000	148,000	ASL/MMP	820,000	81,000	148,000
49	NO TREAT	0	0	0	MMP	540,000	42,000	100,000	MMP	540,000	42,000	100,000
	Treat STMI				Mix IIII				Mix IIII			
63	ASL	1,100,000	160,000	390,000	ASL/MMF	4,200,000	449,000	960,000	ASL/MMP	4,200,000	449,000	580,000
66	CLAR	2[illegible],000	18,000	44,000	CLAR/MMF	810,000	66,000	155,000	CLAR/MMP	810,000	66,000	158,000
81	ASL	750,000	38,000	190,000	ASL/MMF	1,090,000	120,000	265,000	ASL/MMP	1,220,000	126,000	285,000
86	NO TREAT	0	0	0	ASL/MMF	1,660,000	167,000	370,000	ASL/MMP	1,660,000	167,000	370,000
88	CLAR	220,000	18,000	43,000	MMF	590,000	47,000	115,000	MMF	590,000	47,000	115,000
92	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
98	MMF	650,000	56,000	130,000	MMF	65,000	58,000	130,000	ASL/MMP	650,000	56,000	130,000
117	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
119	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	625,000	52,000	140,000
121	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
122	NO TREAT	0	0	0	MMF	650,000	56,000	130,000	MMF	650,000	56,000	130,000
151	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
153	ASL	700,000	72,000	170,000	ASL/MMF	1,045,000	104,000	245,000	ASL/MMP	1,045,000	104,000	245,000
158	CLAR	110,000	17,000	31,000	MMF	370,000	34,000	80,000	MMP	370,000	34,000	80,000
159	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
164	ASL	700,000	72,000	170,000	ASL/MMF	1,030,000	106,[illegible]00	250,000	ASL/MMF	1,060,000	106,000	250,000
176	CLAR	190,000	18,000	40,000	MMF	560,000	44,000	110,000	MMF	560,000	44,000	110,000
182	NO TREAT	0	0	0	MMP	450,000	39,000	90,000	ASL/MMP	1,250,000	122,000	280,000
187	ASL	1,500,000	150,000	363,000	ASL/MMP	2,125,000	202,000	480,000	ASL/MMP	2,325,000	222,000	540,000
192	DAF	76,000	15,000	24,000	MMF	250,000	25,000	60,000	MMP	250,000	25,000	60,000

TARGET IV (15/20)

Plant #	Treatment	Capital $	Operational $	Annual $
8	ASL/MMF	740,000	75,000	179,000
31	MMF	550,000	44,000	108,000
32	ASL/MMF	620,000	61,000	148,000
49	MMF Mix I & II	540,000	42,000	100,000
63	ASL/MMF	4,200,000	449,000	960,000
66	CLAR/MMF	810,000	66,000	159,000
81	ASL/MMF	1,220,000	126,000	285,000
86	ASL/MMF	1,660,000	167,000	370,000
88	ASL/MMF	1,150,000	120,000	260,000
92	No Treat	0	0	0
98	ASL/MMF	650,000	56,000	130,000
117	No Treat	0	0	0
119	MMF	625,000	52,000	140,000
121	No Treat	0	0	0
122	MMF	650,000	56,000	130,000
151	MMF	700,000	64,000	148,000
153	ASL/MMF	1,045,000	104,000	245,000
158	ASL/MMF	700,000	73,000	170,000
159	MMF	460,000	39,000	90,000
164	ASL/MMF	1,060,000	106,000	250,000
176	MMF	560,000	44,000	110,000
182	ASL/MMF	1,250,000	122,000	280,000
187	ASL/MMF	2,325,000	222,000	540,000
192	MMF	250,000	25,000	60,000

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TABLE 8-15 (cont), NON-PLASTICS

Plant No.	TARGET I (50/50) Suggested Treatment	TARGET I (50/50) Capital Costs ($)	TARGET I (50/50) Operating Costs ($/yr)	TARGET I (50/50) Annual Costs ($/yr)	TARGET II (30/30) Suggested Treatment	TARGET II (30/30) Capital Costs ($)	TARGET II (30/30) Operating Costs ($/yr)	TARGET II (30/30) Annual Costs ($/yr)	TARGET III (20/20) Suggested Treatment	TARGET III (20/20) Capital Costs ($)	TARGET III (20/20) Operating Costs ($/yr)	TARGET III (20/20) Annual Costs ($/yr)
193	ASL	850,000	110,000	220,000	ASL/MMP	1,235,000	141,000	303,000	ASL/MMP	1,535,000	171,000	373,000
195	NO TREAT	0	0	0	MMP	1,050,000	85,000	210,000	MMP	1,050,000	85,000	210,000
201	ASL	480,000	57,000	120,000	ASL/MMF	518,000	72,000	139,000	ASL/MMP	710,000	83,000	173,000
203	ASL	510,000	50,000	130,000	ASL/MMP	760,000	75,000	187,000	ASL/MMP	790,000	79,000	197,000
205	CLAR	30,000	14,000	18,000	MMP	160,000	15,000	34,000	MMP	160,000	15,000	34,000
206	CLAR	350,000	22,000	64,000	MMF	850,000	75,000	170,000	MMF	850,000	75,000	170,000
208	NO TREAT	0	0	0	MMP	400,000	36,000	85,000	MMP	420,000	36,000	85,000
230	ASL	700,000	72,000	170,000	ASL/MMP	1,050,000	104,000	246,000	ASL/MMP	1,050,000	104,000	246,000
235	ASL	2,300,000	270,000	560,000	ASL/MMP	3,200,000	350,000	750,000	ASL/MMP	3,200,000	350,000	750,000
236	CLAR	330,000	22,000	62,000	MMF	800,000	75,000	170,000	MMP	800,000	75,000	170,000
245	NO TREAT	0	0	0	NO TREAT	0	0		NO TREAT	0	0	0
248	ASL	1,300,000	130,000	290,000	ASL/MMP	1,525,000	181,000	410,000	ASL/MMP	1,525,000	181,000	410,000
249	NO TREAT	0	0	0	NOT TREAT	0	0		NO TREAT	0	0	0
258	NO TREAT	0	0	0	ASL/MMP	550,000	59,000	138,000	ASL/MMP	550,000	58,000	138,000
* 6	ASL	510,000	58,000	130,000	ASL/MMF	755,000	81,000	182,000	ASL/MMP	815,000	83,000	194,000
* 81	ASL	510,000	58,000	130,000	ASL/MMF	755,000	81,000	182,000	ASL/MMF	815,000	83,000	194,000
* 163	ASL	410,000	44,000	107,000	ASL/MMP	815,000	61,000	147,000	ASL/MMP	615,000	61,000	147,000
* 204	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	270,000	26,000	62,000
* 259	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
* 268	ASL	2,200,000	320,000	580,000	ASL/MMF	2,880,000	380,000	720,000	ALA/MMP	3,880,000	350,000	840,000
* 281	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
TOTALS		17,253,000	1,973,000	4,229,000		35,483,000	3,807,000	8,050,00		39,130,000	3,815,000	8,780,000

*INSUFFICIENT TSS DATA.

TARGET IV (15/20)

Plant #	Treatment	Capital $	Operational $	Annual $
193	ASL/MMF	1,535,000	171,000	373,000
195	MMF	1,050,000	85,000	210,000
201	ASL/MMF	710,000	83,000	173,000
203	ASL/MMF	790,000	79,000	197,000
205	MMF	160,000	15,000	34,000
206	ASL/MMF	2,100,000	250,000	510,000
208	MMF	400,000	36,000	85,000
230	ASL/MMF	1,050,000	104,000	246,000
235	ASL/MMF	3,200,000	350,000	750,000
236	ASL/MMF	2,000,000	230,000	490,000
245	No Treat	0	0	0
248	ASL/MMF	1,925,000	181,000	410,000
249	No Treat	0	0	0
258	ASL/MMF	550,000	59,000	136,000
6	ASL/MMF	815,000	83,000	194,000
81	ASL/MMF	815,000	83,000	194,000
163	ASL/MMF	615,000	61,000	147,000
204	MMF	270,000	26,000	62,000
259	No Treat	0	0	0
268	ALA/MMF	3,880,000	350,000	840,000
281	MMF	540,000	42,500	100,000
TOTALS		44,170,000	4,401,500	10,013,000

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TABLE 8-16 PLANT-BY-PLANT SUGGESTED TREATMENT AND COSTS, PLASTICS

	TARGET I (50/50)				TARGET II (30/30)				TARGET III (25/20)			
Plant No.	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)
2	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	640,000	54,000	127,000
3	NO TREAT	0	0	0	ASL/MMP	690,000	99,000	233,000	ASL/MMP	990,000	95,000	233,000
5	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	240,000	22,000	[illegible]
10	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
17	NO TREAT	0	0	0	ASL/MMP	680,000	67,000	160,000	ASL/MMP	680,000	67,000	[illegible]
19	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
[illegible]	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	1,750,000	120,000	[illegible]
29	CLAR	485,000	25,000	83,000	MMP	1,250,000	95,000	245,000	MMP	1,250,000	95,000	245,000
34	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	240,000	20,000	50,000
39	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
44	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
45	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	650,000	56,000	[illegible]
54	NO TREAT	0	0	0	MMP	280,000	26,000	58,000	MMP	280,000	26,000	58,000
65	NO TREAT	0	0	0	MMP	1,250,000	95,000	245,000	MMP	1,250,000	95,000	245,000
[illegible]	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
77	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
89	CLAR	220,000	15,000	48,000	MMP	625,000	52,000	120,000	MMP	625,000	52,000	120,000
90	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
91	CLAR	250,000	19,000	50,000	MMP	650,000	56,000	130,000	MMP	650,000	56,000	130,000
92	DAP	80,000	15,000	24,000	MMP	260,000	26,000	60,000	MMP	260,000	26,000	60,000
99	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
[illegible]	NO TREAT*	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
104	CLAR	270,000	19,000	45,000	MMP	600,000	50,000	120,000	MMP	600,000	50,000	120,000

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*Mix multiple streams for optimum annual cost.

TARGET IVA (10/20)

Plant #	Treatment	Capital $	Operational $	Annual $
2	MMF	640,000	54,000	127,000
3	ASL/MMF	990,000	99,000	233,000
9	MMF	240,000	22,000	52,000
10	No Treat	0	0	0
17	ASL/MMF	680,000	67,000	160,000
19	No Treat	0	0	0
27	ASL/MMF	5,400,000	680,000	1,400,000
29	MMF	1,250,000	95,000	245,000
34	ASL/MMF	450,000	49,000	115,000
39	No Treat	0	0	0
44	MMF	470,000	40,000	92,000
45	MMF	650,000	56,000	130,000
54	MMF	280,000	28,000	68,000
65	ASL/MMF	3,400,000	410,000	830,000
73	No Treat	0	0	0
77	No Treat	0	0	0
89	ASL/MMF	1,300,000	140,000	300,000
90	No Treat	0	0	0
91	MMF	650,000	56,000	130,000
93	MMF	260,000	26,000	60,000
96	No Treat	0	0	0
100	No Treat	0	0	0
104	MMF	600,000	50,000	120,000

TABLE 8-16 (cont), PLASTICS

Plant No.	TARGET I (50/50) Suggested Treatment	TARGET I (50/50) Capital Costs ($)	TARGET I (50/50) Operating Costs ($/yr)	TARGET I (50/50) Annual Costs ($/yr)	TARGET II (30/30) Suggested Treatment	TARGET II (30/30) Capital Costs ($)	TARGET II (30/30) Operating Costs ($/yr)	TARGET II (30/30) Annual Costs ($/yr)	TARGET III (20/20) Suggested Treatment	TARGET III (20/20) Capital Costs ($)	TARGET III (20/20) Operating Costs ($/yr)	TARGET III (20/20) Annual Costs ($/yr)
105	NO TREAT	0	0	0	MMF	340,000	32,000	75,000	MMF	340,000	32,000	75,000
107	CLAR	270,000	20,000	52,000	MMF	700,000	62,000	140,000	MMF	700,000	62,000	140,000
109	CLAR	220,000	19,000	45,000	MMF	600,000	50,000	120,000	MMF	600,000	50,000	120,000
111	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
124	NO TREAT	0	0	0	ASL/MMF	1,070,000	106,000	248,000	ASL/MMF	1,070,000	108,000	248,000
125	NO TREAT	0	0	0	ASL/MMF	1,210,000	116,000	270,000	ASL/MMF	1,210,000	118,000	270,000
126	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	360,000	34,000	80,000
132	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
146	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	360,000	34,000	80,000
147	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	330,000	31,000	73,000
150	NO TREAT	0	0	0	ASL/MMF	1,300,000	126,000	285,000	ASL/MMF	1,300,000	128,00	285,000
152	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
157	NO TREAT	0	0	0	MMF	600,000	46,000	110,000	MMF	600,000	46,000	110,000
174	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
179	NO TREAT	0	0	0	MMF	420,000	38,000	85,000	MMF	420,000	38,000	85,000
					Mix I+II				Mix I + II			
184	NO TREAT	0	0	0	NO TREAT	0	0	0	MMF	580,000	46,000	110,000
189	ASL	680,000	70,000	160,000	ASL/MMF	1,020,000	102,000	235,000	ASL/MMF	1,020,000	102,000	235,000
194	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
196	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
202	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
210	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
217	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0

TARGET IVA (10/20)

Plant #	Treatment	Capital $	Operational $	Annual $
105	MMF	340,000	32,000	75,000
107	ASL/MMF	1,600,000	175,000	370,000
109	MMF	600,000	50,000	120,000
111	No Treat	0	0	0
124	ASL/MMF	1,070,000	108,000	248,000
125	ASL/MMF	1,210,000	118,000	270,000
126	MMF	360,000	34,000	80,000
132	ASL	640,000	66,000	155,000
146	MMF	360,000	34,000	80,000
147	MMF	330,000	31,000	73,000
150	ASL/MMF	1,300,000	126,000	285,000
152	No Treat	0	0	0
157	MMF	600,000	46,000	110,000
174	No Treat	0	0	0
179	MMF Mix I & II	420,000	38,000	85,000
184	MMF	560,000	46,000	110,000
189	ASL/MMF	1,020,000	102,000	235,000
194	No Treat	0	0	0
196	No Treat	0	0	0
202	ASL	540,000	58,000	135,000
210	No Treat	0	0	0
217	ASL	420,000	44,000	107,000

TABLE 8- 16(cont), PLASTICS

Plant No.	TARGET I (50/50)				TARGET II (30/30)				TARGET III (20/20)			
	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)	Suggested Treatment	Capital Costs ($)	Operating Costs ($/yr)	Annual Costs ($/yr)
223	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
224	DAP	78,000	14,000	23,000	MMF	250,000	23,000	52,000	MMP	250,000	23,000	52,000
229	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
248	ASL	780,000	84,000	190,000	ASL/MMF	1,190,000	121,000	275,000	ASL/MMP	1,190,000	121,000	275,000
254	NO TREAT	0	'0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
262	CLAR	105,000	17,000	30,000	MMP	340,000	32,000	75,000	MMP	340,000	32,000	75,000
273	CLAR	330,000	22,000	61,000	MMF	775,000	70,000	160,000	MMP	775,000	70,000	160,000
277	NO TREAT	0	0	0	MMF	675,000	60,000	135,000	MMP	675,000	60,000	135,000
287	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
* 75	NO TREAT	0	0	0	NO TREAT	0	0	0	MMP	390,000	35,000	80,000
* 108	NO TREAT	0	0	0	NO TREAT	0	0	0	NO TREAT	0	0	0
* 233	NO TREAT	0	0	0	MMF	450,000	39,000	90,000	MMP	450,000	39,000	90,000
TOTALS		3,716,000	344,000	809,000		17,525,000	1,595,000	3,738,000		25,685,000	2,337,000	5,483,000

*INSUFFICIENT TSS DATA.

TARGET IVA (10/20)

Plant #	Treatment	Capital $	Operational $	Annual $
223	ASL	480,000	40,000	94,000
224	ASL/MMF	470,000	52,000	120,000
229	No Treat	0	0	0
246	ASL/MMF	1,190,000	121,000	275,000
254	MMF	510,000	41,000	96,000
262	ASL/MMF	660,000	68,000	160,000
273	ASL/MMF	200,000	230,000	480,000
277	MMF	675,000	60,000	135,000
287	No Treat	0	0	0
75	ASL/MMF	730,000	75,000	175,000
106	No Treat	0	0	0
233	ASL/MMF	830,000	85,000	190,000
TOTALS		36,175,000	3,752,000	8,325,000

TABLE 8-17

POTENTIAL BPT EFFLUENT LIMITATIONS

BPT (I)

Subcategory	BOD mg/l	TSS mg/l
Plastics	14.5	24
Not Plastics -Type I with Oxidation		
High Flow	26.0	62
Low Flow	36.0	89
Not Plastics Type I w/o Oxidation	24.5	34.5
Not Plastics NOT Type I	17.0	29

BPT (II)

Subcategory	BOD mg/l	TSS mg/l
Plastics	14.5	23
Not Plastics - Type I with Oxiation		
High Flow	26.0	42
Low Flow	36.0	42
Not Plastics Type I w/o Oxidation	24.5	27
Not Plastics NOT Type I	17.0	26

TABLE 8-18

PLANT-BY-PLANT COST ESTIMATES

SUBCATEGORY: PLASTICS ONLY

	BPT (I)				BPT (II)			
Plant #	Suggested Treatment	Capital Cost ($)	Operating Cost($/yr)	Annual Cost($/yr)	Suggested Treatment	Capital Cost($/yr)	Operating Cost($/yr)	Annual Cost($/yr)
2	No Treat.	0	0	0	MMF	640,000	54,000	127,000
3	ASL/MMF	990,000	99,000	233,000	ASL/MMF	990,000	99,000	233,000
9	MMF	240,000	22,000	52,000	MMF	240,000	22,000	52,000
10	No Treat.	0	0	0	No Treat.	0	0	0
17	ASL/MMF	680,000	67,000	160,000	ASL/MMF	680,000	67,000	160,000
19	No Treat.	0	0	0	No Treat.	0	0	0
29	MMF	1,250,000	95,000	245,000	MMF	1,250,000	95,000	245,000
39	No Treat.	0	0	0	No Treat.	0	0	0
45	No Treat.	0	0	0	No Treat.	0	0	0
54	ASL/MMF	880,000	88,000	218,000	ASL/MMF	880,000	88,000	218,000
73	No Treat.	0	0	0	No Treat.	0	0	0
77	No Treat.	0	0	0	No Treat.	0	0	0
90	No Treat.	0	0	0	No Treat.	0	0	0
91	MMF	650,000	56,000	130,000	MMF	650,000	56,000	130,000
93	MMF	260,000	26,000	60,000	MMF	260,000	26,000	60,000
96	No Treat.	0	0	0	No Treat.	0	0	0
100	No Treat.	0	0	0	No Treat.	0	0	0
104	MMF	600,000	50,000	120,000	MMF	600,000	50,000	120,000
105	MMF	340,000	32,000	75,000	MMF	340,000	32,000	75,000
109	MMF	600,000	50,000	120,000	MMF	600,000	50,000	120,000
111	No Treat.	0	0	0	No Treat.	0	0	0
124	ASL/MMF	1,070,000	108,000	248,000	ASL/MMF	1,070,000	108,000	248,000
125	ASL/MMF	1,210,000	118,000	270,000	ASL/MMF	1,210,000	118,000	270,000
126	MMF	360,000	34,000	80,000	MMF	360,000	34,000	80,000
146	No Treat.	0	0	0	No Treat.	0	0	0
147	MMF	330,000	31,000	73,000	MMF	330,000	31,000	73,000
150	ASL/MMF	1,300,000	126,000	285,000	ASL/MMF	1,300,000	126,000	285,000
152	No Treat.	0	0	0	No Treat.	0	0	0
157	MMF	600,000	46,000	110,000	MMF	600,000	46,000	110,000

TABLE 8-18 (Continued)

PLANT-BY-PLANT COST ESTIMATES

SUBCATEGORY: PLASTICS ONLY

	BPT (I)				BPT (II)			
Plant #	Suggested Treatment	Capital Cost ($)	Operating Cost($/yr)	Annual Cost($/yr)	Suggested Treatment	Capital Cost($/yr)	Operating Cost($/yr)	Annual Cost($/yr)
174	No Treat.	0	0	0	No Treat.	0	0	0
179	MMF	420,000	38,000	85,000	MMF	420,000	38,000	85,000
184	MMF	560,000	46,000	110,000	MMF	560,000	46,000	110,000
189	ASL/MMF	1,020,000	102,000	235,000	ASL/MMF	1,020,000	102,000	235,000
196	ASL/MMF	2,640,000	290,000	615,000	ASL/MMF	2,640,000	290,000	615,000
210	No Treat.	0	0	0	No Treat.	0	0	0
229	No Treat.	0	0	0	No Treat.	0	0	0
246	ASL/MMF	1,190,000	121,000	275,000	ASL/MMF	1,190,000	121,000	275,000
277	MMF	675,000	60,000	135,000	MMF	675,000	60,000	135,000
287	No Treat.	0	0	0	No Treat.	0	0	0
27	MMF	1,750,000	120,000	300,000	ASL/MMF	7,150,000	800,000	1,700,000
34	ASL/MMF	690,000	64,000	165,000	ASL/MMF	690,000	64,000	165,000
44	No Treat.	0	0	0	No Treat.	0	0	0
52	No Treat.	0	0	0	No Treat.	0	0	0
65	MMF	1,250,000	95,000	245,000	MMF	1,250,000	95,000	245,000
75	ASL/MMF	1,120,000	110,000	255,000	ASL/MMF	1,120,000	110,000	255,000
89	ASL/MMF	1,925,000	192,000	420,000	ASL/MMF	1,925,000	192,000	420,000
107	ASL/MMF	1,900,000	237,000	510,000	ASL/MMF	1,900,000	237,000	510,000
119	No Treat.	0	0	0	MMF	125,000	52,000	140,000
134	MMF	320,000	31,000	71,000	ASL/MMF	960,000	97,000	226,000
192	MMF	250,000	25,000	60,000	ASL/MMF	750,000	78,000	190,000
202	MMF	290,000	26,000	60,000	ASL/MMF	830,000	84,000	195,000
217	MMF	210,000	16,000	41,000	MMF	210,000	16,000	41,000
223	No Treat.	0	0	0	MMF	480,000	40,000	94,000
224	ASL/MMF	720,000	75,000	172,000	ASL/MMF	720,000	75,000	172,000
233	ASL/MMF	980,000	119,000	280,000	ASL/MMF	980,000	119,000	280,000
254	No Treat.	0	0	0	MMF	510,000	47,000	96,000
262	ASL/MMF	1,000,000	100,000	235,000	ASL/MMF	1,000,000	100,000	235,000
273	ASL/MMF	2,775,000	300,000	640,000	ASL/MMF	2,775,000	300,000	640,000

TABLE 8-18 (Continued)

PLANT-BY-PLANT COST ESTIMATES

SUBCATEGORY: TYPE I W/ OXIDATION - HIGH FLOW

	BPT (I)				BPT (II)			
Plant #	Suggested Treatment	Capital Cost ($)	Operating Cost($/yr)	Annual Cost($/yr)	Suggested Treatment	Capital Cost($/yr)	Operating Cost($/yr)	Annual Cost($/yr)
20	ASL	500,000	52,000	130,000	ASL/MMF	740,000	74,000	180,000
31	CLR	185,000	18,000	40,000	MMF	550,000	44,000	108,000
36	ASL	600,000	58,000	145,000	ASL/MMF	840,000	78,000	195,000
49	No Treat.	0	0	0	No Treat.	0	0	0
57	MMF	720,000	65,000	150,000	MMF	720,000	65,000	150,000
60	MMF	900,000	80,000	190,000	MMF	900,000	80,000	190,000
61	ASL	1,550,000	170,000	360,000	ASL/MMF	2,220,000	230,000	495,000
62	ASL	1,150,000	120,000	260,000	ASL/MMF	1,750,000	168,000	375,000
63	ASL	3,100,000	360,000	740,000	ASL/MMF	4,200,000	449,000	960,000
76	No Treat.	0	0	0	No Treat.	0	0	0
80	No Treat.	0	0	0	No Treat.	0	0	0
84	ASL	2,850,000	335,000	680,000	ASL/MMF	3,900,000	420,000	890,000
98	ASL	1,400,000	150,000	330,000	ASL/MMF	2,050,000	206,000	460,000
102	No Treat.	0	0	0	No Treat.	0	0	0
103	No Treat.	0	0	0	No Treat.	0	0	0
110	No Treat.	0	0	0	No Treat.	0	0	0
112	ASL	930,000	95,000	210,000	ASL/MMF	1,430,000	136,000	307,000
113	No Treat.	0	0	0	No Treat.	0	0	0
114	No Treat.	0	0	0	MMF	850,000	77,000	170,000
127	ASL	1,400,000	130,000	310,000	ASL/MMF	1,960,000	174,000	420,000
175	MMF	520,000	44,000	98,000	MMF	520,000	44,000	98,000
176	MMF	560,000	44,000	110,000	MMF	560,000	44,000	110,000
187	ASL	1,700,000	170,000	420,000	ASL/MMF	2,325,000	222,000	540,000
193	ASL	1,200,000	140,000	300,000	ASL/MMF	1,535,000	171,000	373,000
195	No Treat.	0	0	0	No. Treat.	0	0	0
216	No Treat.	0	0	0	No Treat.	0	0	0
220	ASL	450,000	55,000	120,000	ASL/MMF	700,000	80,000	176,000
222	ASL	1,100,000	120,000	270,000	ASL/MMF	1,450,000	152,000	346,000
228	ASL	1,900,000	220,000	450,000	ASL/MMF	2,650,000	290,000	610,000
234	No Treat.	0	0	0	No Treat.	0	0	0

TABLE 8-18 (Continued)

PLANT-BY-PLANT COST ESTIMATES

SUBCATEGORY: TYPE I W/ OXIDATION - HIGH FLOW

	BPT (I)				BPT (II)			
Plant #	Suggested Treatment	Capital Cost ($)	Operating Cost($/yr)	Annual Cost($/yr)	Suggested Treatment	Capital Cost($/yr)	Operating Cost($/yr)	Annual Cost($/yr)
235	ASL	2,300,000	270,000	560,000	ASL/MMF	3,200,000	350,000	750,000
248	ASL	1,300,000	130,000	290,000	ASL/MMF	1,925,000	181,000	410,000
249	No Treat.	0	0	0	No Treat.	0	0	0
257	ASL	870,000	90,000	210,000	ASL/MMF	1,330,000	129,000	302,000
272	CLR	340,000	22,000	62,000	MMF	800,000	75,000	170,000
88	ASL	1,150,000	120,000	260,000	ASL/MMF	1,740,000	167,000	375,000
158	ASL	700,000	73,000	170,000	ASL/MMF	1,070,000	107,000	250,000
206	MMF	850,000	75,000	170,000	MMF	850,000	75,000	170,000
236	MMF	800,000	75,000	170,000	MMF	800,000	75,000	170,000

SUBCATEGORY: TYPE I W/ OXIDATION - LOW FLOW

	BPT (I)				BPT (II)			
Plant #	Suggested Treatment	Capital Cost ($)	Operating Cost($/yr)	Annual Cost($/yr)	Suggested Treatment	Capital Cost($/yr)	Operating Cost($/yr)	Annual Cost($/yr)
42	ASL	490,000	54,000	125,000	ASL/MMF	720,000	73,000	170,000
50	No Treat.	0	0	0	MMF	320,000	30,000	72,000
81	ASL	750,000	88,000	190,000	ASL/MMF	1,090,000	120,000	265,000
81	ASL	510,000	56,000	130,000	ASL/MMF	765,000	81,000	188,000
81 (total 2 streams)		1,260,000	144,000	320,000		1,855,000	201,000	453,000
138	ASL	800,000	103,000	230,000	ASL/MMF	1,220,000	141,000	315,000
160	ASL	760,000	80,000	175,000	ASL/MMF	1,180,000	118,000	260,000
163	ASL	410,000	44,000	107,000	ASL/MMF	615,000	61,000	147,000
177	No Treat.	0	0	0	No Treat.	0	0	0
188	No Treat.	0	0	0	No Treat.	0	0	0
218	ASL	380,000	43,000	103,000	ASL/MMF	565,000	60,000	141,000
219	CLR	55,000	16,000	22,000	MMF	230,000	20,000	48,000
239	No Treat.	0	0	0	No Treat.	0	0	0
268	ASL	2,200,000	320,000	580,000	ASL/MMF	2,880,000	380,000	720,000
271	CLR	185,000	18,000	40,000	MMF	560,000	44,000	110,000

TABLE 8-18 (Continued)

PLANT-BY-PLANT COST ESTIMATES

SUBCATEGORY: Type I w/o Oxidation

	BPT (I)				BPT (II)			
Plant #	Suggested Treatment	Capital Cost ($)	Operating Cost($/yr)	Annual Cost($/yr)	Suggested Treatment	Capital Cost($/yr)	Operating Cost($/yr)	Annual Cost($/yr)
1	ASL/MMF	1,330,000	178,000	295,000	ASL/MMF	1,330,000	178,000	295,000
15	No Treat.	0	0	0	No Treat.	0	0	0
16	ALA/MMF	5,850,000	537,000	1,270,000	ALA/MMF	5,850,000	537,000	1,270,000
28	MMF	740,000	68,000	155,000	MMF	740,000	68,000	155,000
32	ASL/MMF	620,000	61,000	148,000	ASL/MMF	620,000	61,000	148,000
35	No Treat.	0	0	0	No Treat.	0	0	0
53	MMF	675,000	60,000	135,000	MMF	675,000	60,000	135,000
64	No Treat.	0	0	0	No Treat.	0	0	0
85	MMF	340,000	32,000	75,000	MMF	340,000	32,000	75,000
117	No Treat.	0	0	0	No Treat.	0	0	0
118	No Treat.	0	0	0	No Treat.	0	0	0
128	No Treat.	0	0	0	MMF	650,000	68,000	150,000
130	No Treat.	0	0	0	No Treat.	0	0	0
164	ASL/MMF	1,060,000	106,000	750,000	ASL/MMF	1,060,000	106,000	750,000
171	MMF	600,000	50,000	120,000	MMF	600,000	50,000	120,000
170	MMF	700,000	64,000	145,000	MMF	700,000	64,000	145,000
178	ASL/MMF	3,100,000	303,000	720,000	ASL/MMF	3,100,000	303,000	720,000
183	No Treat.	0	0	0	No Treat.	0	0	0
201	ASL/MMF	710,000	83,000	173,000	ASL/MMF	710,000	83,000	173,000
203	ASL/MMF	790,000	79,000	197,000	ASL/MMF	790,000	79,000	197,000
204	No Treat.	0	0	0	No Treat.	0	0	0
230	ASL/MMF	1,050,000	104,000	246,000	ASL/MMF	1,050,000	104,000	246,000
256	No Treat.	0	0	0	MMF	270,000	26,000	64,000
259	No Treat.	0	0	0	No Treat.	0	0	0
263	MMF	205,000	17,000	41,000	MMF	205,000	17,000	41,000
264	No Treat.	0	0	0	No Treat.	0	0	0
269	ASL/MMF	2,900,000	315,000	670,000	ASL/MMF	2,900,000	315,000	670,000
275	ASL/MMF	800,000	84,000	195,000	ASL/MMF	800,000	84,000	195,000
159	No Treat.	0	0	0	No Treat.	0	0	0
281	No Treat.	0	0	0	No Treat.	0	0	0

TABLE 8-18 (Continued)

PLANT-BY-PLANT COST ESTIMATES

SUBCATEGORY: NOT TYPE I

	BPT (I)				BPT (II)			
Plant #	Suggested Treatment	Capital Cost ($)	Operating Cost($/yr)	Annual Cost($/yr)	Suggested Treatment	Capital Cost($/yr)	Operating Cost($/yr)	Annual Cost($/yr)
6	ASL/MMF	815,000	83,000	194,000	ASL/MMF	815,000	83,000	194,000
8	ASL/MMF	890,000	90,000	208,000	ASL/MMF	890,000	90,000	208,000
18	No Treat.	0	0	0	No Treat.	0	0	0
21	No Treat.	0	0	0	No Treat.	0	0	0
59	MMF	600,000	50,000	120,000	MMF	600,000	50,000	120,000
66	MMF	810,000	66,000	159,000	MMF	810,000	66,000	159,000
86	ASL/MMF	1,660,000	167,000	370,000	ASL/MMF	1,660,000	167,000	370,000
92	No Treat.	0	0	0	No Treat.	0	0	0
94	MMF	5,000,000	250,000	850,000	MMF	5,000,000	250,000	850,000
97	MMF	520,000	42,000	100,000	MMF	520,000	42,000	10,000
120	No Treat.	0	0	0	MMF	2,500,000	150,000	450,000
121	No Treat.	0	0	0	No Treat.	0	0	0
122	MMF	650,000	56,000	130,000	ASL/MMF	1,700,000	166,000	370,000
144	MMF	540,000	42,000	100,000	ASL/MMF	1,020,000	94,000	220,000
145	ASL/MMF	1,800,000	180,000	400,000	ASL/MMF	1,800,000	180,000	400,000
153	ASL/MMF	1,045,000	104,000	245,000	ASL/MMF	1,045,000	104,000	245,000
182	ASL/MMF	1,250,000	122,000	[illegible],000	ASL/MMF	1,250,000	122,000	280,000
186	No Treat.	0	0	0	No Treat.	0	0	0
205	MMF	160,000	15,000	34,000	MMF	160,000	15,000	34,000
208	MMF	400,000	36,000	85,000	ASL/MMF	830,000	81,000	195,000
226	MMF	560,000	46,000	110,000	MMF	560,000	46,000	110,000
231	ASL/MMF	1,270,000	156,000	332,000	ASL/MMF	1,270,000	156,000	332,000
245	No Treat.	0	0	0	No Treat.	0	0	0
247	No Treat.	0	0	0	No Treat.	0	0	0
258	ASL/MMF	550,000	59,000	136,000	ASL/MMF	550,000	59,000	136,000
270	No Treat.	0	0	0	No Treat.	0	0	0
151	MMF	700,000	64,000	148,000	MMF	700,000	64,000	148,000

TABLE 8-19

TOTAL COSTS, PLANT-BY-PLANT ANALYSIS

	BPT (I)			BPT (II)		
	Capital Cost ($)	Operating Cost ($/Yr)	Annual Cost ($/Yr)	Capital Cost ($)	Operating Cost ($/Yr)	Annual Cost ($/Yr)
PLASTICS	33,045,000	3,215,000	7,388,000	41,875,000	4,265,000	9,665,000
TYPE I W/ OXID.						
-High Flow	31,025,000	3,281,000	7,205,000	43,565,000	4,363,000	9,682,000
-Low Flow	6,540,000	824,000	1,702,000	10,145,000	1,128,000	2,436,000
TYPE I W/O OXID.	21,470,000	2,141,000	5,335,000	22,390,000	2,235,000	5,549,000
NOT TYPE I	19,220,000	1,628,000	4,001,000	23,680,000	1,985,000	4,921,000
TOTAL	111,300,000	11,089,000	25,631,000	141,290,000	13,950,000	32,253,000

TABLE 8-20

PERCENTAGE OF PLANTS REQUIRING ADDITIONAL TREATMENT FOR BPT (I)

Subcategory	No Additional Treatment	ASL/MMF	MMF	ASL	CLAR
Plastics Only	38	29	33	0	0
Not Plastics - Type I W/ Oxidation					
-High Flow	31	0	15	49	5
-Low Flow	31	0	0	54	15
Not Plastics -Type I W/O Oxidation	47	30	20	0	0
Not Plastics NOT Type I	33	30	37	0	0

3% require ALA/MMF (Not Plastics - Type I W/O Oxidation)

TABLE 8-21

PERCENTAGE OF PLANTS REQUIRING ADDITIONAL TREATMENT FOR BPT (II)

Subcategory	No Additional Treatment	ASL/MMF	MMF	ASL	CLAR
Plastics Only	31	36	33	0	0
Not Plastics - Type I W/Oxidation					
-High Flow	28	49	23	0	0
-Low Flow	23	54	23	0	0
Not Plastics -Type I W/O Oxidation	40	30	27	0	0
Not Plastics NOT Type I	30	40	30	0	0

3% require ALA/MMF (Not Plastics - Type I W/O Oxidation)

TABLE 8-22

PERCENTAGE OF ANNUAL COSTS BY SUBCATEGORY

Subcategory	BPT (I)	BPT (II)
PLASTICS 58 Plants (35% of data base)	29	30
NOT PLASTICS - TYPE I W/ OXIDATION		
-High Flow 39 Plants (23% of data base)	28	30
-Low Flow 13 Plants (8% of data base)	7	8
NOT PLASTICS - TYPE I W/O OXIDATION 30 Plants (18% of data base)	21	17
NOT PLASTICS - NOT TYPE I 27 Plants (16% of data base)	15	15
167 Total Plants (100%)	100%	100%

CAPDET REPRODUCIBILITY

Following completion of the cost estimates used to prepare this report, an attempt was made to verify the reproducibility of the CAPDET program. In conducting this evaluation it was determined that the CAPDET program had been revised since the original cost analyses. Neither the EPA nor the Corps of Engineers has available documentation of the earlier version of CAPDET from which the costs were generated.

To determine the extent of the revisions, a set of activated sludge system costs were run using input values identical to those used in an earlier run for which printouts were available. The technologies designed and costed included primary clarification, complete mix activated sludge (with secondary clarifier), gravity thickening, sludge drying and contract hauling.

Both series of runs using the old and revised CAPDET showed identical designs and costs for primary and secondary clarifier, gravity thickener, drying beds and similar costs for hauling. However, the designs and costs for the complete mix activated sludge system were different. Comparing a 1000 mg/l BOD influent at 0.2 MGD and a 20 mg/l (LTM) effluent target, the sizing of the reactor by the revised version was larger, but cost less. A 4.86 MG vessel with costs of $1.07 million for the revised CAPDET versus 3.69 MG vessel costing $1.31 million for the older version.

FURTHER CHANGES TO CAPDET

Following this analysis some further revisions were made to CAPDET. The major difference in the design of OCPS industry wastewater treatment systems, compared with domestic or sanitary wastewater treatment systems, is the slower rate at which biological oxidation reactions proceed. Typically, the kinetic rate for the BOD degradation of OCPS wastewater is one-half to one-fifth the rate for domestic wastewater. In addition, the influent BOD concentration for a domestic wastewater treatment system usually falls within a relatively narrow range, typically from 200 to 350 mg/l. Influent BOD concentrations for OCPS industry treatment systems can range from less than one hundred to several thousand mg/l. On this basis, the kinetic model used by CAPDET was modified as shown in Table 8-1. As an alternative to the use of this model, the necessary programming changes were made to incorporate a kinetic model specifically intended for industrial wastewater.

Research, provided by Gloyna, Grau, and any others in the industrial waste field has found the Grau kinetic model more closely simulates actual biochemical removal or organics.[8-8] Union Carbide has completed extensive study on the use of Grau kinetics to model its chemical plants. The resulting conclusion is that BOD removal has been determined to be first order as a function of soluble BOD and volatile solids but inversely proportionate to the influent soluble BOD concentration. The work is described in an article by Cyron T. Lawson, *et al*. in "Comments on Selected Aspects of Activated Sludge Treatment Technology Based on Recent Union Carbide Experience".

The use of soluble, rather than total, influent BOD concentrations represents a constraint when applying the Grau model to develop industry-wide treatment costs. Very few plants in the OCPS data base reported soluble influent BOD characteristics. To apply the Grau model to plants which reported only total influent BOD data, some relationship between total and soluble BOD would have to be assumed. Errors in this assumption may offset the benefits of using a more accurate kinetic modeling technique.

NON WATER QUALITY ASPECTS

The use of wastewater treatment systems to alleviate water pollution problems may result in adverse impacts in other environmental areas. Elements of other environmental concerns that must be considered include:

1. Air pollution
2. Solid waste generation
3. RCRA considerations
4. Noise pollution
5. Energy requirements

Air Pollution

If solvents or other volatile hydrocarbons are subjected to an evaporative process (such as an evaporation pond) where vapor condensation is impractical, volatile materials will be lost to the atmosphere. Volatile materials can be lost to a lesser extent through aeration, dissolved air flotation and other treatment operations. The extent of the pollution potential depends on the nature and concentration of the volatile components and on the weather conditions at the site of disposal or treatment, as well as the treatment technology itself.

Landfilling is a fairly common method of disposing of settled solids, floating oils and biological sludges. If the landfill is not properly designed and maintained, volatile components in the nonwater wastes can evaporate and contribute to air pollution.

Incineration is another commonly employed method for the disposal of nonaqueous wastes. Improperly designed or operated incinerators can discharge particulates, hydrocarbons or noxious gases to the atmosphere. Most of these emissions can be controlled by the use of scrubbers. These scrubbers will, however, create an additional source of contaminated wastewater.

Solid Waste Generation

Solid wastes, for the purposes of this report, include the solids and skimmings produced by the treatment technologies involved in the primary, secondary and tertiary end-of-pipe treatment of the OCPS industry's wastewater.

The solids include such materials as grit and solids from primary clarifiers, sludges and skimmings generated by the various separation technologies, biological sludge from biological treatment plants, spent activated carbon and residues from incineration. Most of the above solids generated cannot be quantified without a specific on-site evaluation; either by the individual plant records, if available, or by a study to determine the quantity of solid waste generated.

The major quantity of solid waste generated, however, is the excess biological sludge. This material can be approximtely quantified because, in biological treatment, the excess sludge is directly related to the BOD removed. CAPDET used 0.73 pounds of sludge generated per pound of BOD removed. Figure 8-14 shows the sludge production as a function of the change in BOD concentration.

RCRA Considerations

Processing operations and treatment facilities in OCPS plants generate solid and liquid wastes which in some cases may be classified as "hazardous wastes" by the definition and characteristics outlined in Section 3001 of the Resource Conservation and Recovery Act (RCRA). Storage, transport, treatment and disposal methods for these wastes are regulated by RCRA interim status standards.

OCPS hazardous waste generators using contract removal, offsite disposal and sales must comply with the transportation guidelines for hazardous waste. The guidelines include standards for manifest, labels, containers, marking and placarding of wastes before removal. The receiver of the wastes would then be responsible for meeting treatment, storage and disposal requirements.

Onsite treatment of hazardous waste by OCPS generators does not have to comply with transportation guidelines for hazardous wastes. They must, however, meet standards for treatment, storage and disposal of these wastes (RCRA Section 3004) and must obtain a permit (RCRA Section 2005). OCPS generators treating onsite include EOP systems and zero discharge performers using deep wells, incineration followed by scrubbing, evaporation ponds and land disposal.

Noise Generation

None of the alternate technologies presented in this report are judged to be generators of excessive noise levels. Most industrial installations, including the OCPS plants, do generate a background noise level which, if excessive, must be accommodated under OSHA regulations. Furthermore, practically all machinery of recent manufacture is constructed or installed to comply with OSHA noise level requirements.

None of the technologies proposed, nor the equipment associated with the technologies, are unique or radically different from other industrial machinery in respect to noise generation.

On this basis it is judged that noise pollution does not pose a potential problem with the implementation of the suggested technologies.

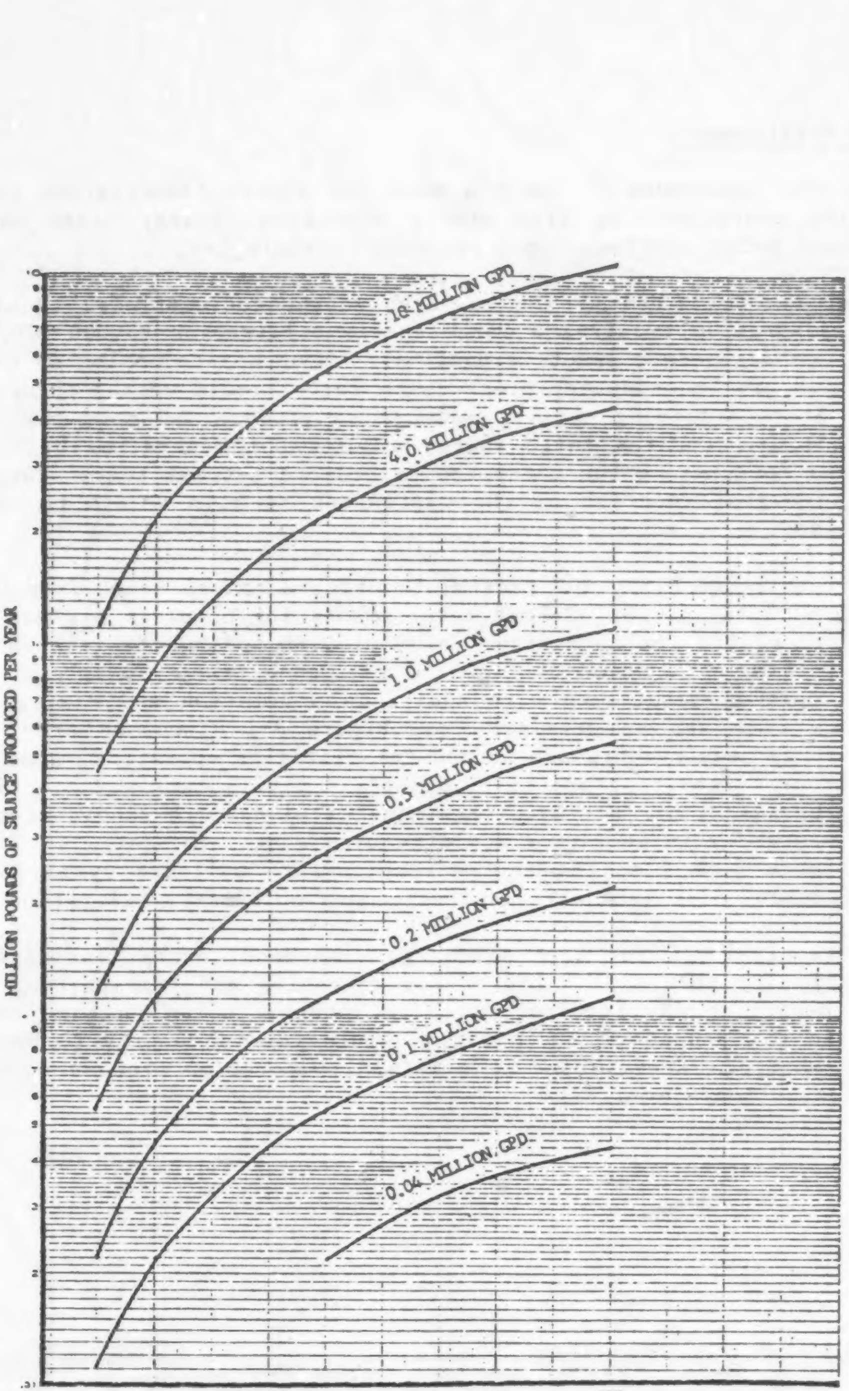

FIGURE 8-14 - SLUDGE PRODUCTION FOR COMPLETE MIX ACTIVATED SLUDGE

Energy Requirements

Due to the importance of today's need for energy conservation and the inceasing costs arising from energy shortages, energy usage must be considered before implementing treatment technologies.

In-plant technologies may require high energy consumptions. Activated carbon adsorption requires a large energy utilization (3,000 BTU/lb of carbon) to regenerate spent carbon.[8-9] Membrane technologies require energy for use in producing pressure to force liquid wastes through the film. Steam stripping utilizes energy to produce and move the steam. Wet oxidation requires large energy amounts for generating high pressures and for fueling the operation to promote extreme temperatures unless the organic content of the wastewater is high enough to sustain auto-oxidation.

Energy requirements for EOP treatments using aerators range from 0.6 to 1.15 hp/1000 ft^3.[8-10] Energy requirements for complete mix activated sludge calculated for an average value of 0.88 hp/1000 ft^3 are shown in Figure 8-15 as a function of flow and residence time. These costs also include pumping requirements in addition to aeration and mixing. The residence time can be obtained from Figure 8-1 discussed previously. Other energy requirements are needed for clarifier operation, some types of filtration requiring pressure, dissolved air flotation and activated carbon regeneration. Ultimate treatment of sludge, residues, scums and liquid wastes by incineration would require additional energy. Figures 8-16 through 8-18 list the energy requirements utilized by CAPDET for clarification, dissolved air flotatation and multimedia filtration.

Energy requirements for zero discharge treatment, except incineration, are mainly for pumping liquids or for operating and transporting vehicles. Recycling may require additional energy to return the recycled wastes to the process. Incineration would rely on energy to heat and oxidize wastes. Energy used to maintain evaporation process equipment must also be considered.

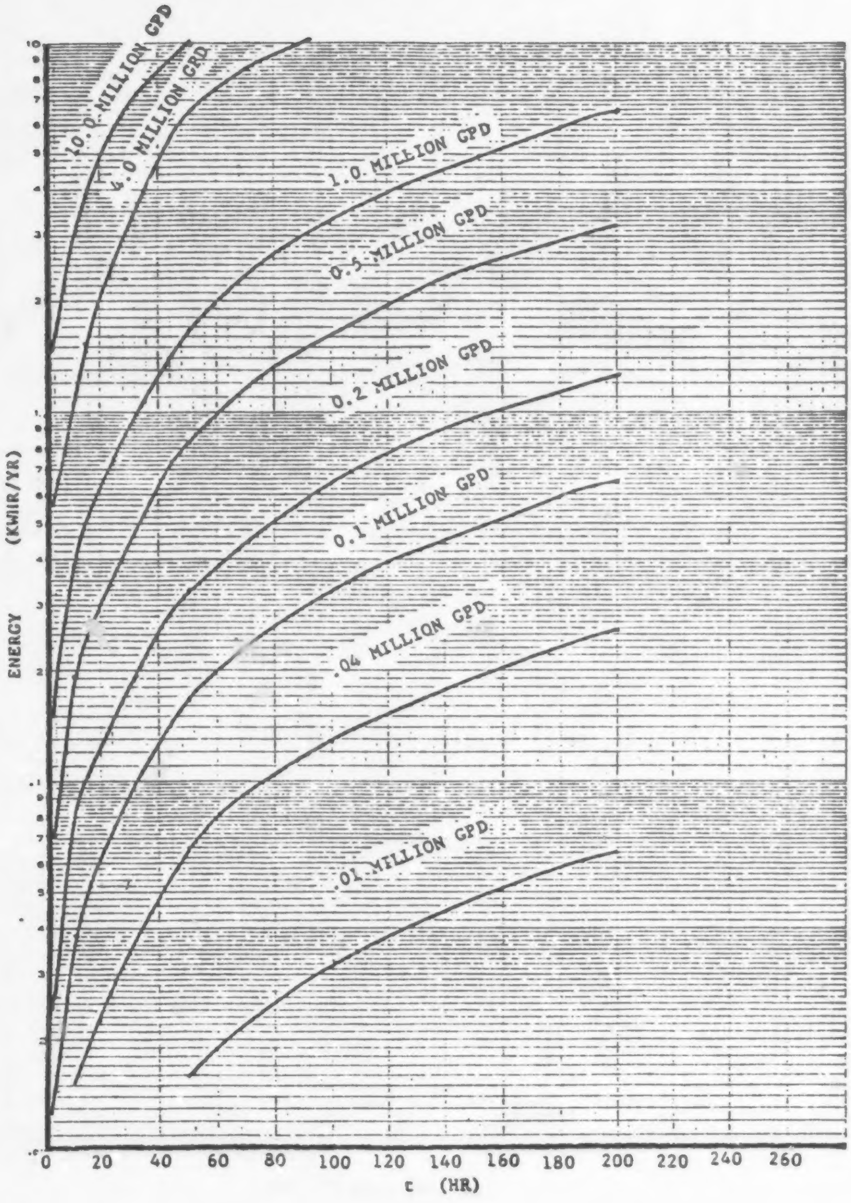

FIGURE 8-15 - ENERGY REQUIREMENTS FOR COMPLETE MIX ACTIVATED SLUDGE

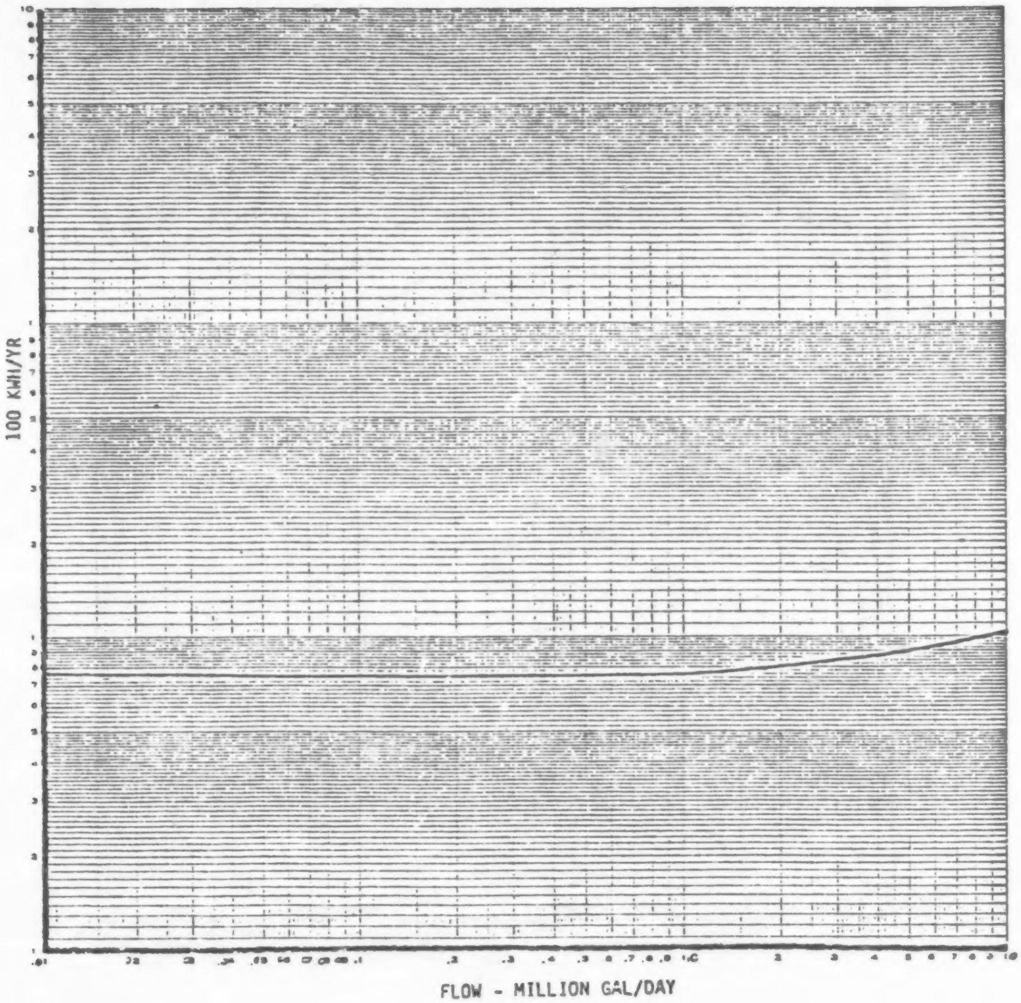

FIGURE 8-16 - ENERGY REQUIREMENTS FOR CLARIFICATION

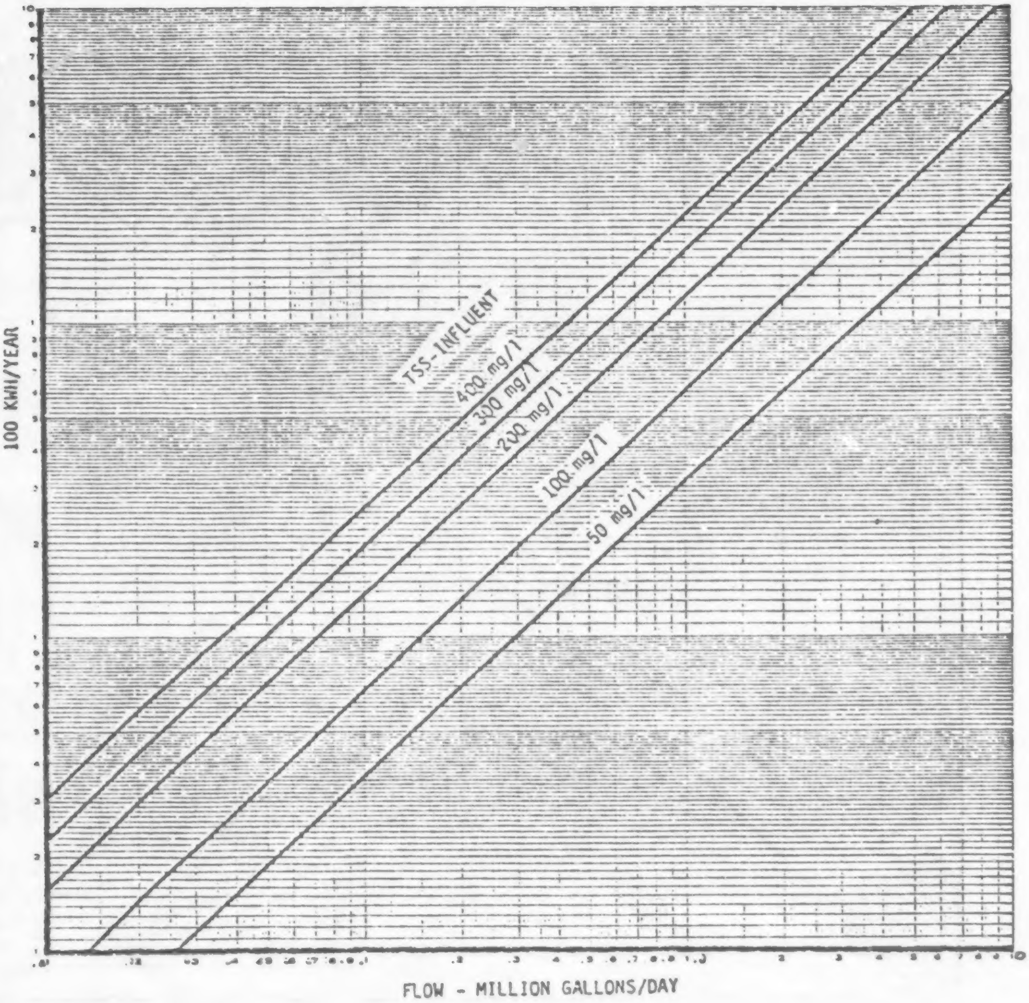

FIGURE 8-17 - ENERGY REQUIREMENTS FOR DISSOLVED AIR FLOTATION

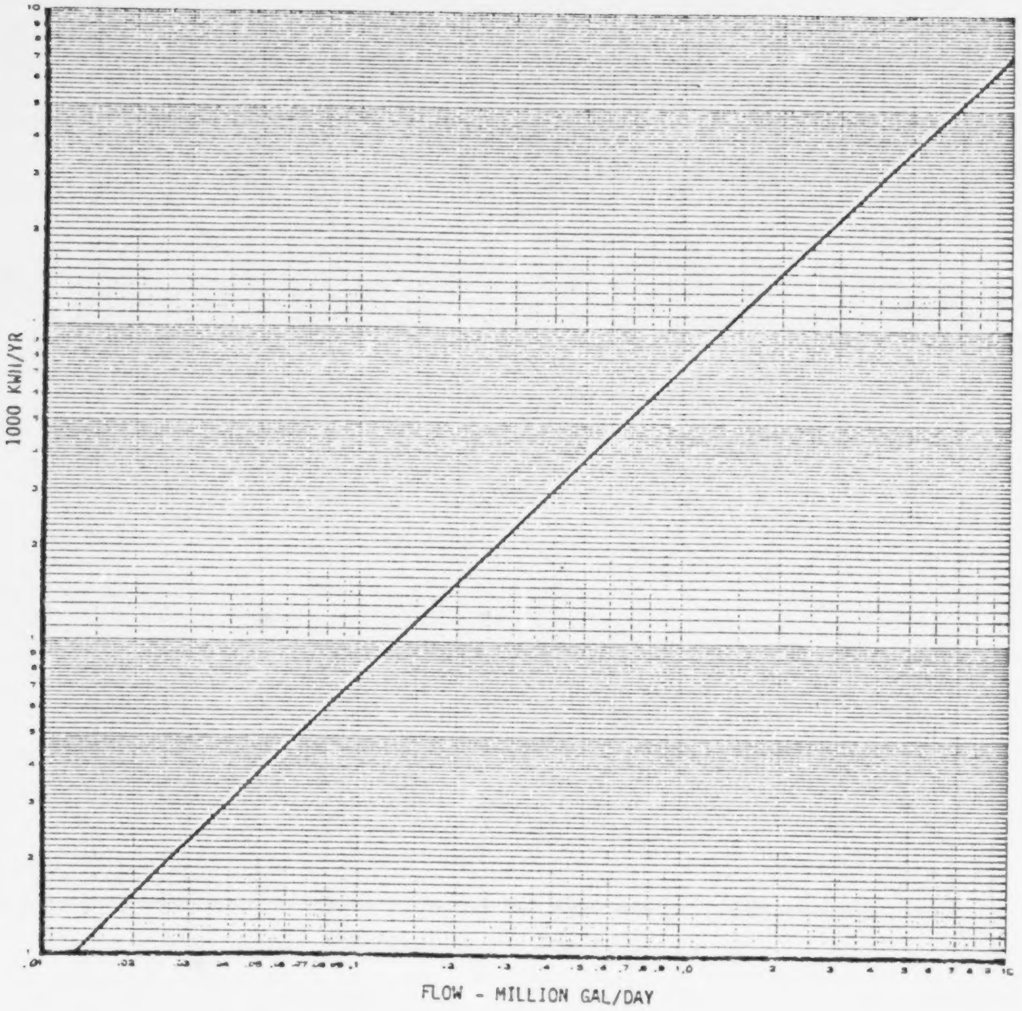

FIGURE 8-18 - ENERGY REQUIREMENTS FOR MULTIMEDIA FILTRATION

SECTION IX.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

GENERAL

The effluent limitations which were required to be achieved by July 1, 1977, are based on the degree of effluent reduction attainable through the application of the best practicable control technology currently available (BPT). The best practicable control technology currently available generally is based upon the average of the best existing performance, in terms of treated effluent discharged, by plants of various sizes, ages, and unit processes within an industry or subcategory. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. Limitations based on transfer technology must be supported by a conclusion that the technology is, indeed, transferable and a reasonable prediction that it will be capable of achieving the prescribed effluent limits (see Tanners' Council of America v. Train, 540 F. 2d 1188 (4th Cir. 1976)). While best practicable control technology currently available focuses on end-of-pipe treatment technology rather than process changes or internal controls, it can include process changes or internal controls when the changes or controls are normal practice with an industry.

BPT considers the total cost of the application of technology in relation to the effluent reduction benefits to be achieved from the technologies. The cost/benefit inquiry for BPT is a limited balancing, which does not require the Agency to quantify benefits in monetary terms (see, e.g., American Iron and Steel v. EPA, 526 F 2d 1027 (3rd Cir. 1975)). In balancing costs in relation to effluent reduction benefits, EPA considers the volume and nature of existing discharges, the volume and nature of discharges expected after application of BPT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control level. The Act does not require or permit consideration of water quality problems attributable to particular point sources or industries, or water quality improvements in particular water bodies (see Weyerhaeuser Company v. Costle, 11 ERC 2149 (D.C. Cir. 1978)).

REGULATED POLLUTANTS

Pollutants proposed for regulation under BPT are BOD_5, TSS and pH.

IDENTIFICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY

In determining the best practicable control technology, biological treatment has been evaluated as the principal treatment practice within the OCPS industry. Of the 185 plants for which treatment system information is available, 146 use some form of biological treatment. Although nonbiological treatment systems are often used to produce high quality effluents, only biological treatment has been sufficiently applied to be considered across the broad spectrum of the OCPS industry. On this basis, biological treatment, in general, may be considered the best technology for treatment of OCPS wastewaters and is, therefore, chosen as best practicable control technology.

RATIONALE FOR SELECTION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY

Use of biological treatment as the best practicable control technology will produce high quality effluents as shown in Section VII. Evaluations to determine if the addition of tertiary treatment processes such as polishing ponds, filtration, carbon adsorption, etc., would improve effluent quality indicated that plants with tertiary processes do not achieve lower effluent BOD_5 concentrations than plants utilizing only biological systems. This apparent contradiction may have resulted from the fact that, because the data base is limited to performance data for entire treatment systems, performance data are not available for individual unit treatment processes. This tends to mask the effect of plants which install additional end-of-pipe treatment technologies to compensate for poorly designed or poorly operated existing treatment systems. Therefore, it was determined that the evaluation of levels of performance by the treatment technology utilized by OCPS plants was not appropriate.

Of the 143 plants in the Summary Data Base which employ biological treatment and have effluent BOD_5 data, only 65 plants, or 46%, comply with applicable BOD_5 effluent limitations, while the remaining 78 plants, or 55%, were not in compliance. In addition, of the 129 plants in the Summary Data Base which employ biological treatment and have effluent TSS data, only 60 plants, or 47%, comply with applicable TSS effluent limitations, while the remaining 69 plants, or 53%, were not in compliance. This is an indication that, while biological treatment has been demonstrated to achieve low effluent concentrations, the median values obtained for all biological systems in the industry are not considered to be representative of the average level of treatment which can be achieved. While some plants in the data base are well designed and operated to the maximum potential, others are operating at less than optimum performance. In order to segregate good performers from bad performers, it was necessary to develop a test to distinguish the better plants from those operating less efficiently.

The first test used to define the well operated plants was to consider only those plants which achieved BOD_5 removals equal to or greater than 95%. As presented in Section VII, plants which meet this test criteria achieve lower median values than do all plants with biological systems. However, it was also recognized that use of the 95% removal criteria eliminates some plants which achieve lower effluent BOD_5 concentrations, but by virtue of having very low influent BOD_5 concentrations, do not achieve 95% removal.

In an attempt to address this potential inconsistency, a new segment was evaluated which included all plants which achieved 95% BOD_5 reduction or which achieved a final effluent BOD_5 concentration of less than or equal to 50 mg/l. This also allowed the inclusion of effluent BOD_5 data which had no corresponding influent value.

In addition, while reviewing the data for this segment, it appeared that well operated plants in the Not Plastics Only-Type I with Oxidation subcategory had a wide range of effluent values. Subsequent investigations showed that this effect appeared to be related to the efficiency of water use by plants in this subcategory. Water use efficiency was defined as a plant's daily water usage divided by its daily production level. As described in detail in Section VII, a further analysis showed this effect to be limited to those plants in the first quartrile of water use. This included plants with water use less than or equal to 0.2 gallons per pound of product. This suggested that the Not Plastics Only - Type I with Oxidation subcategory be further divided into low water use (less than 0.2 gallons per pound) and high water use (greater than 0.2 gallons per pound) subcategories. When this was done, the resulting long term median final effluent BOD_5 and TSS concentrations for plants with at least 95% BOD_5 removal or 50 mg/l final effluent BOD_5 concentrations were 26 mg/l and 62 mg/l for high water use facilities and 36 mg/l and 89 mg/l for low water use facilities.

After the calculation of long term median effluent concentration for each proposed subcategory, EPA grouped for analysis all plants which performed better than the subcategory long term median and all plants which performed worse. This analysis was performed to determine if certain plant characteristics would cause plants to perform better or worse than the subcategory long term median. The results showed that both groups have similar mixes and numbers of generic processes, similar ranges in the number of specific product processes, similar raw waste concentration distributions, similar contributions from secondary production of non-OCPS products and geographical mix (as a measure of temperature effects). Therefore, it can be concluded that different types of plants were not improperly combined within a subcategory.

The implementation of additional end-of-pipe treatment technologies can require additional land. In addition, spatial relationships and the physical characteristics of available land can affect construction costs. However, as detailed in Section VIII, the cost of land acquisition has been included in cost estimates, where appropriate. In addition, the impact of plant-by-plant variations has been lessened by costing least land intensive options available (i.e., activated sludge versus aerated lagoons).

BPT EFFLUENT LIMITATIONS

BPT effluent limitations are presented in Table 9-1.

METHODOLOGY USED FOR DEVELOPMENT OF BPT EFFLUENT LIMITATIONS

Biological treatment has been identified as the best practicable control technology currently available for each of the four proposed subcategories. The long term median BPT final effluent BOD_5 and TSS concentrations were calculated for each subcategory by using the performance of plants which attain 95% BOD_5 reduction or a final effluent BOD_5 concentration less than or equal to 50 mg/l. In addition, after a review of data and information submitted by the industry, it was determined that four plants which met the above BOD criteria had installed more advanced

TABLE 9-1

BPT EFFLUENT LIMITATIONS
(mg/l or ppm)

	LONG TERM MEDIAN		MAXIMUM 30-DAY		MAXIMUM DAILY	
SUBCATEGORY	BOD_5	TSS	BOD5	TSS	BOD_5	TSS
Plastics Only	14.5	24	22	36	49	117
Oxidation						
o High Water Use	26	62	42	84	106	246
o Low Water Use	36	89	58	120	146	353
Type I	24.5	34.5	40	47	100	137
Other Discharges	17	29	28	39	69	115

pH - All subcategories - Within a range of 6.0 to 9.0 at all times wastewater treatment technology in order to meet permit conditions based on water quality standards. It was determined that the performance of these four plants (three plants in the Plastics Only subcategory and one plant in the Other Discharges subcategory) was not representative of this technology-based regulation and therefore, were removed from the calculation of effluent limitations. Remaining plants were determined to achieve the best existing performance.

Maximum 30-day and daily maximum effluent limitations were determined by multiplying long-term median effluent concentrations by appropriate variability factors which were calculated through statistical analysis of long term BOD_5 and TSS daily data. This statistical analysis is described in detail in Section VII.

COST OF APPLICATION AND EFFLUENT REDUCTION BENEFITS

Summary Data Base

The total cost (1979 dollars) of attainment of BPT effluent limitations for the 130 direct discharging plants in the Summary Data Base which do not meet these limitations has been estimated to be about 111.30 million dollars in capital cost with associated total annual cost of about 25.63 million dollars per year.

Conventional pollutant removals from current discharge loadings associated with Summary Data Base plants have been estimated to be about 9.79 million kg/yr (21.58 million lbs/yr) of BOD_5 and 14.59 million kg/yr (32.17 million lbs/yr) of TSS. These removals represent a cost per pound of BOD and TSS removed of about $0.48/lb. of BOD and TSS removed. Percent removals of BOD and TSS from current raw waste loads are estimated to be about 94.8 percent and 74.6 percent, respectively. Table 9-2 presents the annual pounds removed figures for each proposed subcategory.

Total Industry

The total cost of attainment of BPT effluent limitations for all direct discharging plants in the OCPS industry has been projected to be about 316 million dollars in capital costs with associated total annual costs of about 105 million dollars per year. These projections were made for use in the Economic Impact Analysis (EIA) and are documented in the EIA document.

As discussed in previous sections of this document, many different estimates have been made on the number of plants in the OCPS industry. Estimates range from about 1200 plants to as many as 2100 plants. Due to the many estimates of the number of direct discharging plants in the OCPS industry, a direct projection of the Summary Data Base to the entire industry was not possible and a general analysis was utilized to project the conventional pollutant removals to the entire OCPS industry. Weighted averages of current BOD_5 and TSS concentrations and current flows for each subcategory were utilized to calculate current total industry BOD and TSS loadings. Using the same weighted average for current flows, total industry BOD and TSS loadings were calculated using

TABLE 9-2

EFFLUENT REDUCTION BENEFITS AND NON WATER QUALITY IMPACTS FOR SUMMARY DATA BASE PLANTS IN EACH OF THE PROPOSED SUBCATEGORIES

	Million lbs/yr Removed		Energy Requirements (Barrels/yr)	Additional Solid Waste (Tons/yr)
	BOD	TSS		
PLASTICS ONLY	1.75	6.01	29,455	3,311
OXIDATION				
o High Water Use	6.50	4.34	84,137	3,307
o Low Water Use	2.72	0.65	6,771	800
TYPE I	9.68	11.09	24,188	7,239
OTHER DISCHARGERS	0.93	10.08	12,444	5,203
TOTALS	21.58	32.17	156,995	19,860

the proposed effluent limitations. The difference in these two total industry loadings was used as the total BOD and TSS removals from current discharge levels. A summary of this case study is shown in Table 9-3. As can be seen in Table 9-3, conventional pollutant removals from current discharge levels based on attainment of BPT effluent limitations have been projected to be about 67.59 million kg/yr (149 million pounds) of BOD and 46.27 million kg/yr (102 million pounds) of TSS. These removals represent a cost per pound of BOD and TSS removed of about $0.42/lb. of BOD and TSS removed. Percent removals of BOD and TSS from current raw waste loads are similar to those for the Summary Data Base.

NON-WATER QUALITY ENVIRONMENTAL IMPACTS

Non-water quality environmental impacts have also been considered in Section VIII. The impacts associated with attainment of BPT effluent limitations by Summary Data Base plants are discussed below. Non-water quality impacts based on total industry attainment of the BPT effluent lmitations are not discussed below due to difficulties associated with projecting Summary Data Base impacts. However, general conclusions on impacts can be drawn from the Summary Data Base statistics.

ENERGY

Attainment of BPT will require the use of the equivalent of approximately 32.69 million liters (157 thousand barrels) of residual fuel oil per year for Summary Data Base plants. Table 9-2 presents a breakdown of the energy requirement by subcategory.

SOLID WASTE

Attainment of BPT will result in an additional 18.02 thousand kkg/yr (19,860 tons/yr) of wastewater treatment solids for plants in the Summary Data Base. Table 9-2 presents the amount of additional solids generated by subcategory.

AIR AND NOISE

Attainment of BPT will have no measurable impact on air or noise pollution.

TABLE 9-3

CASE STUDY FOR ESTIMATING TOTAL INDUSTRY DIRECT DISCHARGE LOADINGS FOR BOD_5 AND TSS

	mg/l	million lbs/year[3]	
BOD_5			
Mean raw waste[1]	945	3,153.9	
Current effluent[1]	63	208.3	Δ 148.8
BPT effluent[2]	18	59.5	
TSS			
Mean raw waste[1]	427	1,401.7	
Current effluent[1]	63	208.3	Δ 102.5
BPT effluent[2]	32	105.8	

[1] mean of all plants in Summary Data Base

[2] median value of all biological systems with BOD_5 removal $\geq$ 95% or effluent $BOD_5 \leq 50$ mg/l

[3] based on 330 operating days per year, 2.31 MGD per plant, and 520 direct discharge plants

SECTION X

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY EFFLUENT LIMITATIONS GUIDELINES

GENERAL

The 1977 amendments added Section 301(b)(2)(E) to the Act, establishing "best conventional pollutant control technology" (BCT) for discharges of conventional pollutants from existing industrial point sources. Section 304(a)(4) designated the following as conventional pollutants: BOD, TSS, fecal coliform and pH. The Administrator designated oil and grease as "conventional" on July 30, 1979, 44 FR 44501.

BCT is not an additional limitation, but replaces BAT for the control of conventional pollutants. In addition to other factors specified in Section 304(b)(4)(b), the Act requires that BCT limitations be assessed in light of a two-part "cost-reasonableness" test. EPA published a methodology for determining BCT on August 29, 1979 (44 FR 50732). In American Paper Institute v. EPA, 660 F. 2nd 954 (4th Cir. 1981), EPA was ordered to revise the cost test.

The court held that EPA must apply a two-part test. The first test compares the cost for private industry to reduce its conventional pollutants with the costs for Publicly Owned Treatment Works to attain similar reductions in their discharge of these pollutants. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find that limitations are "reasonable" under both tests before establishing them as BCT. In no case may BCT be less stringent than BPT.

In response to the court order, EPA has proposed a revised BCT cost-reasonableness test at 47 FR 49176 (October 29, 1982). The proposed test provides that BCT is cost-reasonable if: (1) the incremental cost per pound of conventional pollutant removed in going from BPT to BCT is less than $.27 per pound in 1976 dollars, and (2) this same incremental cost per pound is less than 143% of the incremental cost per pound associated with achieving BPT.

REGULATED POLLUTANTS

Pollutants proposed for regulation under BCT are BOD_5, TSS and pH.

IDENTIFICATION OF THE BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY

The Agency has considered an incremental technology level of conventional pollutant control beyond BPT. The technology, additional solids control such as polishing ponds and filtration, is already practiced by approximately one third of the plants in the industry.

BCT EFFLUENT LIMITATIONS

BCT effluent limitations are presented in Table 10-1.

TABLE 10-1

BCT EFFLUENT LIMITATIONS
(mg/l or ppm)

	LONG TERM MEDIAN		MAXIMUM 30-DAY		MAXIMUM DAILY	
SUBCATEGORY	BOD_5	TSS	BOD5	TSS	BOD_5	TSS
Plastics Only	14.5	24	22	36	49	117
Oxidation						
o High Water Use	26	62	42	84	106	246
o Low Water Use	36	89	58	120	146	353
Type I	24.5	34.5	40	47	100	137
Other Discharges	17	29	28	39	69	115

RATIONALE FOR THE SELECTION OF BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY

The Agency performed the first part of the BCT "cost-reasonableness" test which compares the cost for private industry to reduce conventional pollutants with the costs for Publicly Owned Treatment Works to attain similar reductions in their discharge of conventional pollutants. To perform this first test, EPA calculated the incremental conventional pollutant removals beyond BPT and the incremental costs associated with the installation of the BCT technology. Based on this information, cost per pound of BOD and TSS removed ratios were calculated for each of the four BPT subcategories. The results of this analysis are presented in Table 10-2.

All the incremental costs per pound ratios were found to fail this first part of the BCT "cost-reasonableness" test ($0.33 per pound in 1979 dollars). Therefore, EPA did not perform the second part of the BCT "cost reasonableness" test, and is proposing BCT effluent limitations which are equal to the BPT effluent limitations for each of the proposed BPT subcategories.

METHODOLOGY USED FOR DEVELOPMENT OF BCT EFFLUENT LIMITATIONS

The methodology used for development of BCT effluent limitations is the same as that used in the development of BPT effluent limitations since BCT effluent limitations are equal to the BPT effluent limitations. For a detailed description of this methodology, refer to Section IX of this document.

COST OF APPLICATION AND EFFLUENT REDUCTION BENEFITS

There are no incremental costs or effluent reduction benefits associated with the attainment of BCT effluent lmitations since BCT effluent limitations are equal to the BPT effluent limitations. For detailed information on the costs and effluent reduction benefits associated with the BPT effluent limitations, refer to Section IX of this document.

NON-WATER QUALITY ENVIRONMENTAL IMPACTS

Incremental non-water quality environmental impacts are associated with the attainment of BCT effluent limitations since BCT effluent limitations are equal to the BPT effluent limitations. For detailed information on the non-water quality impacts associated with the BPT effluent limitations, refer to Section IX.

TABLE 10-2

BCT "COST-REASONABLENESS" TEST RESULTS

Subcategory	Incremental BOD and TSS Removed (pounds/year)	Incremental Cost (1979 $/yr.)	Cost Per Pound of BOD$_5$ and TSS Removed (1979 $/yr.)
PLASTICS ONLY	161,600	2,277,000	$14.09/lb.
OXIDATION			
o High Water Use	2,199,000	2,477,000	$ 1.13/lb.
o Low Water Use	414,000	734,000	$ 1.77/lb.
TYPE I	461,000	214,000	$ 0.46/lb.
OTHER DISCHARGES	604,286	920,000	$ L.52/lb.

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS

GENERAL

The basis for new source performance standards (NSPS) under section 306 of the Act is the best available demonstrated technology. At new plants, the opportunity exists to design the best and most efficient production processes and wastewater treatment facilities. Therefore, Congress directed EPA to consider the best demonstrated process change, in-plant controls and end-of-pipe treatment technologies that reduce pollution to the maximum extent feasible. It is encouraged that at new sources, reductions in the use of and/or discharge of wastewater be attained by application of inplant control measures.

REGULATED POLLUTANTS

Conventional Pollutants

Conventional pollutants proposed for regulation under NSPS are the same as for BPT: BOD_5, TSS and pH.

IDENTIFICATION OF THE TECHNOLOGY BASIS OF NSPS

The technologies employed to control conventional pollutants at existing plants are fully applicable to new plants. In addition, no other technologies could be identified for new sources which were different from those used to establish BPT effluent limitations. Thus, the technology basis for NSPS is the same as that for BPT effluent limitations. For detailed information on the technology basis for BPT effluent limitations, refer to Section IX of this document.

NEW SOURCE PERFORMANCE STANDARDS

New source performance standards for conventional pollutants are presented in Table 11-1.

RATIONALE FOR THE SELECTION OF THE TECHNOLOGY BASIS FOR NSPS

Since the Agency could identify no additional generally applicable technology for NSPS and since the technology basis for NSPS is the same as that identified for BPT effluent limitations, EPA has established NSPS effluent limitations equal to the proposed BPT and BCT effluent limitations.

METHODOLOGY USED FOR DEVELOPMENT OF NSPS EFFLUENT LIMITATIONS

The methodology used for the development of NSPS effluent limitations is the same as that used for the development of BPT effluent limitations. For detailed information on the methodology used to develop the BPT effluent limitations, refer to Section IX of this document.

TABLE 11-1

NSPS EFFLUENT LIMITATIONS
(mg/l or ppm)

	LONG TERM MEDIAN		MAXIMUM 30-DAY		MAXIMUM DAILY	
SUBCATEGORY	BOD_5	TSS	BOD5	TSS	BOD_5	TSS
Plastics Only	14.5	24	22	36	49	117
Oxidation						
o High Water Use	26	62	42	84	106	246
o Low Water Use	36	89	58	120	146	353
Type I	24.5	34.5	40	47	100	137
Other Discharges	17	29	28	39	69	115

pH - All Subcategories - Within a range of 6.0 to 9.0 at all times

COST OF APPLICATION AND EFFLUENT REDUCTION BENEFITS

There are no incremental costs or effluent reduction benefits associated with the attainment of NSPS since NSPS effluent limitations are equal to the BPT effluent limitations. For detailed information on the costs and effluent reduction benefits associated with the attainment of BPT effluent limitations, refer to Section IX of this document.

NON-WATER QUALITY ENVIRONMENTAL IMPACTS

No incremental non-water quality environmental impacts are associated with attainment of NSPS since NSPS effluent lmitations are equal to the BPT effluent limitations. For detailed information on the non-water quality impacts associated with the attainment of BPT effluent lmitations, refer to Section IX of this document.

SECTION XII.

ACKNOWLEDGMENTS

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SECTION XIII.
REFERENCES

3-1 *Riegel's Handbook of Ind. Chem.*, 3rd Edition, Ed. James A. Kent, New York, Van Nostrand Reinhold Company, 1974, p. 772.

3-2 Wittcuff, H. A. and Reuben, B. G., *Ind. Organic Chemistry in Perspective*, *Part 1*, New York, John Wiley & Sons, 1980, p. 40.

4-1 Conover, W. J., *Practical Nonparametric Statistics*, 1st Edition, New York, John Wiley & Sons, 1971, pp. 245-249.

4-2 Kendall, M. G. and Stuart, A., *The Advanced Theory of Statistics*, *Volume 2*, *Inference and Relationship*, New York, Hafner Publishing Company, 1973, pp. 498-502.

5-1 APHA, AWWA and WPCR, *Standard Methods for the Examination of Water and Wastewater*, 4th Edition, Washington, DC, APHA, 19076, p. 549.

5-2 *Ibid.*, p. 94.

5-3 *Ibid.*, pp. 516, 517, 519, 521.

5-4 *Ibid.*, p. 554.

5-5 *Ibid.*, p. 534.

7-1 Troxler, W.L., Parmele, C.S. and Barton, D. A., "Survey of Industrial Applications of Aqueous--Phase Activated--Carbon Adsorption for Control of Pollutant Compounds from Manufacture of Organic Compounds," Enviroscience Corp., Knoxville, TN.

7-2 Knopp, P.V. and Randall, T. L., "Detoxification of Specific Organic Substances by Wet Oxidation," The 51st Annual Conference of Water Pollution Control Federation, 1978.

7-3 Eckenfelder, W.W. and McMullen, E. D., "Factors Affecting the Design and Operation of Activated Sludge Plants Treating Organic Chemicals Wastewaters," *Progress in Water Technology*, Vol. 8, 1976.

7-4 Berthouex, P.M., Hunter, W.G., Pallesen, L. and Shih, C.Y., "The Use of Stochastic Models in the Interpretation of Historical Data From Sewage Treatment Plants," *Water Research*, 10, 1976, p. 689-698.

7-5 Sayigh, B.A., "Temperature Effects on the Activated Sludge Process," Ph.D thesis presented in May 1977, University of Texas at Austin, TX.

7-6 Del Pino, M.P. and Zirk, W.E., "Temperature Effects on Biological Treatment of Petrochemical Wastewaters," *Environmental Progress*, Vol. 1, No. 2, May 1982.

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8-1 Eckenfelder, W.W., Water Quality Engineering for Practicing Engineers, New York, Barnes & Noble, 1970, p. 97, Table 5-16.

8-2 Kovalcik, R.N., "Single Waste Treatment Vessel Both Flocculates and Clarifies," Chemical Engineering, Vol. 85, June 19, 1978, pp. 117-120.

8-3 Thibault, G.T. and Tracy, K.D., "Controlling and Monitoring Activated Sludge Units," Chemical Engineering, vol. 85, September 11, 1978, pp. 155-160.

8-4 Arora, M.L. and Montgomery, J., "Wastewater Treatment in the United States.

8-5 Kenpling, J.D. and Eng. J., "Performance of Dual-Media Filters--2," Chemical Engineering Progress, Vol. 76, April 1977.

8-6 op cit, 8-4.

8-7 op cit, 8-4.

8-8 Grau, P. and Dohanyos, M., "Kinetics of Substrate Removal by Activated Sludge." Vod. Hospod., B20,20 (1970) (Czech.).

8-9 Water Pollution Control Federation and American Society of Civil Engineers, "Wastewater Treatment Plant Design," Manual of Practice No. 8, Lancaster, PA, Lancaster Press, 1977.

8-10 Metcalf and Eddy, Inc., Wastewater Engineering Treatment Disposal Reuse, 2nd Edition, New York, McGraw-Hill, 1979.

E-1 Computer Assisted Procedure for the Design and Evaluation of Wastewater Treatment Systems (CAPDET), Office of Water and Waste Management, U. S. Environmental Protection Agency, Washington, DC, 1980.

E-2 Peters, M.S. and Timmerhaus, K.D., Plant Design and Economics for Chemical Engineers, 2nd Edition, New York, McGraw-hill, 1968, p. 850.

E-3 Brigham, Eugene F., Fundamentals of Financial Management, Hinsdale, IL, Dryden Press, 1978.

E-4 Construction of Municipal Wastewater Treatment Plant: 1973-1977, Washington, DC, Office of Water Program Operation, 1978.

E-5 Department of the Army, Corps of Engineers, Design of Wastewater Treatment Facilities, Major Systems, Part 1, Washington, DC, Office of Chief of Engineers, 1978.

OTHER REFERENCES

Scherm, M. and Lawson, C.T., "Activated Carbon Adsorption of Organic Chemical Manufacturing Wastewaters After Extensive Biological Treatment," Union Carbide Corp., S. Charleston, WV.

Wise, H.E. and Fahrenthold, P.D., "Predicting Priority Pollutants From Petrochemical Processes," *Environmental Science & Technology*, November, 1981.

Conway, R.A., Hougous, J.C. and Macauley, D.C., "Predicting Achievable Effluent Quality and Variability in the Organic Chemical Industry," *Progress in Water Technology*, Vol. 8, Pergamon Press, 1976.

Campbell, H.J. and Rocheleau, R.F., "Waste Treatment at a Complex Plastics Manufacturing Plant," *Journal WPCF*, February 1976.

Ellis, K. V., "The Biological Treatment of Organic Industrial Wastewaters," *Effluent and Water Treatment Journal*, May 1979.

Minor, P.S., "Organic Chemical Industry's Wastewaters," *Environmental Science & Technology*, July 1974.

Adams, C.E. and Davis, G.M., "Biological Treatment for World's Largest Acrylate Plant to Achieve BATEA on Houston Ship Channel," 30th Annual Purdue Ind. Waste Conference, 1975.

Sachs, E.F, Jennett, J.C. and Rand, M.C., "Anaerobic Treatment of Synthesized Organic Chemical Pharmaceutical Wastes."

Sidwick, J.M., "The Treatment of Liquid Waste From the Manufacture of Organic Chemicals--Two Case Histories," *Prog. Wat. Tech.*, Vol. 8, 1976.

Housden, A.J., "Operational Experiences in the Effective Treatment of Effluents from Synthetic Resin Manufacture," *Water Pollution Control*, 1981.

Lawson, C.T. and Bryner, B.J., "Wastewater Renovation and Reuse in an Organic Chemicals Plant--A Pilot-Scale Study," Union Carbide Corp.

Koon, J.H. and Adams, E. E., "Biological and Physical-Chemical Treatment of Waste From a Diversified Organic Chemical Plant," 30th Annual Purdue Ind. Waste Conference, 1975.

Chian, E.S.K., Chang, Y., Dewalle, F.B. and Rose, W.B., "Combined Treatment of an Organic Chemical Water by Activated Sludge Followed by Activated Carbon," Perdue Ind. Waste Conf., 1975.

Ford, D.L. and Eckenfelder, W.W., "Design and Economics of Powdered Activated Carbon in the Activated Sludge Process," *Prog. Water Tech.*, Vol. 12, 1980.

Sidwick, J.M., "The Treatment of an Industrial Effluent From the Manufacture of Organic Chemicals for Process Reuse," _Prog. Water Tech._, Vol. 10, 1978.

Sittig, M., _Pollution Control in the Organic Chemical Industry_, Park Ridge, NJ, Noyes Data Corp., 1974, pp.34-38.

APPENDIX A

GENERIC PROCESS CODES WITH FREQUENCY OF OCCURRENCE

FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS *

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
0005-01	D1	6	.	.	ABS RESIN/EMULSION POLYMERIZATION
0005-02	D1	1	.	.	ABS RESIN/MASS POLYMERIZATION
0005-03	D1	2	.	.	ABS RESIN/SUSPENSION POLYMERIZATION
0005-90	3	3	.	.	ABS RESIN/FINISHING PROCESS
0010-90	1	.	.	.	ABS/SAN/FINISHING PROCESS
0012-01	2	1	.	.	ACENAPHTHENE/BY-PRODUCT OF PROPANE PYROLYSIS
0030-02	C	1	2	.	ACETALDEHYDE/OXIDATION OF ETHYLENE WITH CUCL2 CATALYST
0030-06	C	1	.	.	ACETALDEHYDE/BY-PRODUCT OF ACROLEIN BY PROPYLENE OXID
0030-07	J1	1	.	.	ACETALDEHYDE/CATALYTIC DEHYDROGENATION OF ETHANOL
0070-00	4	.	.	.	ACETIC ACID/
0070-02	C	.	2	.	ACETIC ACID/CATALYTIC OXIDATION OF BUTANE
0070-04	C	1	2	.	ACETIC ACID/OXIDATION OF ACETALDEHYDE
0070-05	O	.	2	.	ACETIC ACID/CARBONYLATION OF METHANOL WITH CO AND H2
0070-07	Z	.	.	.	ACETIC ACID/BY-PRODUCT OF P-AMINOPHENOL BY ACID CLV
0070-08	13	.	.	.	ACETIC ACID/BY-PRODUCT OF DIATRIZOIC ACID
0070-09	G	.	1	.	ACETIC ACID/TRANSESTERIFICATION-METHYLACETATE&FORMICACID
0070-12	D1	.	.	.	ACETIC ACID/BY-PRODUCT POLYVINYL FORMAL
0070-13	E	1	.	.	ACETIC ACID/BY-PRODUCT OF POLYVINYL ALCOHOL(HYDROLYSIS OF POLYVINLE ACETATE)
0070-14	3	.	.	.	ACETIC ACID/RECOVERY FROM POLYOL PROCESS
0070-15	3	.	.	.	ACETIC ACID/RECOVERY FROM SULFITE PULP WASTEWATER
0070-16	C	1	.	.	ACETIC ACID/COPRODUCT OF TPA BY OXIDAT OF ACETALDEHYDE
0075-00	24	.	.	.	ACETIC ACID SALTS/ ACETIC ACID + METAL OXIDE OR HYDROXIDE
0075-99	24	1	1	.	ACETIC ACID SALTS (TOTAL)/ ACETIC ACID + METAL OXIDE (HYDROXIDE)
0080-01	Q	2	1	.	ACETIC ANHYDRIDE/THERMAL CRACKING OF ACETIC ACID
0080-02	Q	2	1	.	ACETIC ANHYDRIDE/FROM ACETIC BY ACID KETENE PROCESS
0090-01	C	6	.	.	ACETONE/CUMENE PEROXIDATION AND ACID CLEAVAGE
0090-03	J1	4	.	.	ACETONE/DEHYDROGENATION OF ISOPROPANOL
0090-08	C	.	1	.	ACETONE/VAPOR-PHASE OXIDATION OF BUTANE/PROPANE
0090-11	C	.	.	.	ACETONE/BYPRODUCT OF H2O2 BY OXIDATION OF ISOPROPANOL
0100-01	Z	1	.	.	ACETONE CYANOHYDRIN/RXN OF ACETONE WITH HYDROCYANIC ACID
0110-01	K	1	.	.	ACETONITRILE/ NH3 + ACETIC ACID,DEHYDRATION OF ACETAMIDE
0110-02	N	.	1	.	ACETONITRILE/BY-PRODUCT OF ACRYLONITRILE BY AMMOXIDATION OF PROPYLENE
0120-01	C	1	.	.	ACETOPHENONE/BY-PRODUCT PHENOL BY CUMENE PEROXIDATION AND ACID CLEAVAGE
0130-01	J2	3	.	.	ACETYLENE/PARTIAL OXIDATION OF METHANE
0130-02	E	.	.	.	ACETYLENE/FROM CALCIUM CARBIDE
0130-03	H	3	1	.	ACETYLENE/BY-PRODUCT OF BY PROPANE PYROLYSIS
0140-01	C	2	.	.	ACROLEIN/OXIDATION OF PROPYLENE
0150-01	E	1	.	.	ACRYLAMIDE/CATALYTIC HYDRATION OF ACRYLONITRILE
0153-01	D1	4	3	.	ACRYLIC LATEX/EMULSION POLYMERIZATION
0155-01	D1	2	2	.	ACRYLIC RESINS/EMULSION POLYMERIZATION
0155-02	D1	2	1	.	ACRYLIC RESINS/SUSPENSION POLYMERIZATION
0155-03	D1	5	3	.	ACRYLIC RESINS/SOLUTION POLYMERIZATION
0155-06	D1	1	2	.	ACRYLIC RESINS/BULK POLYMERIZATION

*Note: Frequency counts reflect only the Summary Data Base which includes 195 Direct Dischargers, 94 Zero Dischargers and 2 unknowns. Product/Processes without frequency counts are from indirect dischargers.

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                    FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR    ZERO    UNK    PP_TEXT

0155-10       D1        1       .       .    ACRYLIC RESINS/BULK POLYMERIZATION TO CAST SHEET
0155-11       D1        1       .       .    ACRYLIC RESINS/EMULSION OR SOLUTION POLYM, TO COATINGS
0155-14       D1        1       .       .    ACRYLIC RESINS/POLYACRYLAMIDE BY SOLUTION POLYMERIZATION
0155-99       D1        1       .       .    ACRYLIC RESINS/PROCESS IN REVIEW
0156-01       D1        2       .       .    ACRYLIC FIHER(85% POLYACRYLONITRILE)/SUSP POLY-WET SPINN
0156-02       D1        2       .       .    ACRYLIC FIHER (85% POLYACRYLONITRILE)SUSP POLY-DRY SPINN
0160-03       O         1       .       .    ACRYLIC ACID/FROM ACETYLENE,CARBON MONOXIDE AND WATER
0160-04       C         1       .       .    ACRYLIC ACID/OXIDATION OF ACROLEIN
0160-80       C         2       1       .    ACRYLIC ACID/OXIDATION OF PROPYLENE VIA ACROLEIN
0165-01       G         3       2       .    ACRYLIC ACID ESTERS/ACRYLIC ACID ESTERIF OF MISC ALCOHOL
0165-04       G         1       .       .    ACRYLIC ACID ESTERS/HYDROXY ALKYL ACRYLATE BY ACRYLIC AL
0165-05       G         1       .       .    ACRYLIC ACID ESTERS/ETHL 2-CYANO ACRLATE FROM FORMALD,ET
0165-06       G         1       .       .    ACRYLIC ACID ESTERS/METHL 2-CYANO ACRLATE FROM FORMALD,E
0165-07       G         1       .       .    ACRYLIC ACID ESTERS/ALLYL 2-CYANO ACRLATE FROM FORMALD,E
0165-09       G         1       .       .    ACRYLIC ACID ESTERS/N-BUTYL ACRYLATE-ACRY ACID+N-BUTANOL
0165-10       G         2       .       .    ACRYLIC ACID ESTERS/ETHYL ACRYLATE-ACRY ACID + ETHANOL
0165-11       G         1       .       .    ACRYLIC ACID ESTERS/ETHYLHEXYL ACRYLATE-ACRY ACID+ETHHEX
0165-12       G         1       .       .    ACRYLIC ACID ESTERS/ISOBUTYL ACRYLATE-ACRY ACID+ISOBUTAN
0165-13       O         1       .       .    ACRYLIC ACID ESTERS/ETHYL ACRYLATE-MODIFIED REPPE PROCES
0165-14       O         1       .       .    ACRYLIC ACID ESTERS/METHY ACRYLATE-MODIFIED REPPE PROCES
0165-15       O         1       .       .    ACRYLIC ACID ESTERS/BUTYL ACRYLATE-MODIFIED REPPE PROCES
0170-00       4         .       1       .    ACRYLONITRILE/
0170-01       N         3       1       .    ACRYLONITRILE/PROPYLENE AMMOXIDATION
0175-01       G         1       .       .    ADIPIC ACID,DI(2-ETHYLHEXYL)ESTER/ESTERIFIC OF ADIPIC AC
0176-01       G         1       .       .    ADIPIC ACID,DI-ISODECYL ESTER/ESTERIFICATION OF ADIPIC A
0177-01       G         1       .       .    ADIPIC ACID,DI-TRIDECYL ESTER/ESTERIFICATION OF ADIPIC A
0179-01       G         1       1       .    ADIPIC ACID ESTERS/ESTERFICATION OF ADIPIC ACID
0180-01       C         .       1       .    ADIPIC ACID/OXIDATION OF CYCLOHEXANOL
0180-02       E         1       .       .    ADIPIC ACID/DEPOLYMERIZATION OF NYLON 6
0180-03       C         .       2       .    ADIPIC ACID/OXIDATION OF CYCLOHEXANOL/ONE MIX
0180-80       C         1       .       .    ADIPIC ACID/ OXIDATION OF CYCLOHEXANE VIA OL/ONE
0185-01       B         .       1       .    ADIPONITRILE/CHLORINATION + CYANATION OF BUTADIENE
0185-03       18        1       .       .    ADIPONITRILE/ DIRECT HYDROCYANATION OF BUTADIENE
0185-04       K         .       1       .    ADIPONITRILE/AMMONOLYSIS OF ADIPIC ACID,DEHYDRATION OF DIAMIDE
0185-05       19        1       .       .    ADIPONITRILE/ELECTROHYDRODIMERIZATION OF ACRYLONITRILE
0186-01       5         1       .       .    ALKOXY ALKANOLS/ ALKOXY ALKANOLS FROM ALKYLENE OXIDE AN
0189-00       D1        .       1       .    ALKYD RESINS/
0189-01       D1        5      15       1    ALKYD RESIN/CONDENSATION POLYMERIZATION
0191-01       I2        2       .       .    ALKYL BENZENES/ALKYLATION OF BENZENE WITH ALPHA-OLEFINS
0192-01       F1        .       1       .    ALKYL AMINES/HYDROGENATION OF FATTY NITRILE
0192-03       K         1       .       .    ALKYL AMINES/AMINATION OF ALCOHOLS
0192-04       Z         1       .       .    ALKYL AMINES/C-13-C19 FROM OLEFIN & HCN & H2
0195-01       I1        1       .       .    ALKYL PHENOLS/NONYL-OCTYL ALKYLATION OF PHENOL
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FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
0195-02	I1	2	.	.	ALKYL PHENOLS/MIXED ALKYLATION OF PHENOL
0200-01	Z	1	.	.	ALLYL ALCOHOL/REDOX OF ACROLEIN AND SEC-BUTANOL(REDUCTION BY ALUMINUM BUTOXIDE)
0200-03	E	1	.	.	ALLYL ALCOHOL/HYDROLYSIS OF ALLYL CHLORIDE
0210-01	R	2	.	.	ALLYL CHLORIDE/CHLORINATION OF PROPYLENE
0230-01	5	.	1	.	AMINOETHYLETHANOLAMINE/RXN OF ETHYLENEDIAMINE + ETH.OXID
0235-05	Z	.	.	.	P-AMINOPHENOL/REDUCTION OF NITROBENZENE-ACID REARRANGE
0240-01	B	.	1	.	AMYL ACETATES/RXN OF ACETIC ACID & AMYL ALCOHOLS
0300-03	F2	.	.	.	ANILINE/BY-PRODUCT OF P-AMINOPHENOL
0300-04	F2	4	.	.	ANILINE/NITROBENZENE HYDROGENATION
0320-01	I1	.	.	.	ANISIDINE/METHYLATION AND REDUCTION
0320-99	4	.	.	.	ANISIDINE/PROCESS UNDER REVIEW
0335-01	2	1	.	.	ANTHRACENE/COAL TAR DISTILLATION
0350-99	C	1	.	.	ANTHRAQUINONE/ OXIDATION OF ANTHRACENE
0358-00	3	.	.	.	ASPIRIN/GENERAL
0358-01	3	.	.	.	ASPIRIN/ACETYLATION OF SALICYLIC ACID
0358-99	B	1	.	.	ASPIRIN/ACETYLATION OF SALICYLIC ACID
0360-03	C	1	.	.	BENZALDEHYDE/OXIDATION OF TOLUENE
0380-00	H	1	.	.	BENZENE/ STEAM PYROLYSIS OF LPG
0380-01	U	3	.	.	BENZENE/HYDRODEALKYLIZATION OF TOLUENE AND/OR XYLENE
0380-02	2	3	.	.	BENZENE/DIST OF BTX EXTRACT,CAT. REFORMATE
0380-04	H	.	.	.	BENZENE/DIST. OF BTX EXTRACT-COAL TAR LIGHT OIL
0380-08	C	1	.	.	BENZENE/BY-PRODUCT OF PHENOL-MFG BY CUMENE OXIDATION (RECOVERED RAW MATERIAL)
0380-09	2	6	1	.	BENZENE/DIST OF BTX EXTRACT-PYROLYSIS GASOLINE
0380-11	2	1	.	.	BENZENE/BY-PRODUCT OF SILICONE MANUFACTURE
0380-12	U	1	.	.	BENZENE/BY-PRODUCT OF STYRENE BY ETHYLBENZ DEHYDROGENATI
0380-13	O	1	.	.	BENZENE/BY-PRODUCT OF ACRYLATE MANUFACTURE (REPPE)
0381-01	2	1	.	.	BTX-BENZENE,TOLUENE,XYLENE(MIXED)/PYROLYSIS GASOLINE FRO
0430-03	C	1	.	.	BENZOIC ACID/OXIDATION OF TOLUENE
0445-01	H	1	.	.	BENZO-A-PYRENE (BY-PRODUCT OF ACETYLENE MFG) / STEAM PYROLYSIS
0495-99	B	1	.	.	BENZOYL PEROXIDE/ BENZOYL CHLORIDE + SODIUM PEROXIDE
0530-01	R	1	.	.	BENZYL CHLORIDE/CHLORINATION OF TOLUENE
0550-99	T	.	.	.	BIPHENYL/BENZENE PASSED THRU HOT TUBE
0554-01	20	1	.	.	BIS-(2-CHLOROISOPROPYL) ETHER/BY-PDCT PROPY OX CHLOROHYD
0560-01	A	4	.	.	BISPHENOL-A/CONDENSATION OF ACETONE WITH PHENOL
0575-01	B	1	.	.	BROMOFORM/ACETONE + SODIUM HYPOBROMITE (HALOFORM REACTION)
0590-01	15	11	2	.	BUTADIENE (1,3)/EXT.DIST. OF C-4 PYROLYZATES
0590-03	J2	1	1	.	BUTADIENE(1,3)/BY DEHYD.OF N-BUTANE AND-OR BU
0590-05	15	.	.	.	BUTADIENE (COPRODUCT OF ETHYLENE BY PYROLYSIS (1770-02)) / BY EXTRACTIVE DISTILLATION
0592-01	2	2	.	.	BUTANE/ NATURAL GAS BY-PRODUCT
0592-02	F2	.	1	.	BUTANE/BYPRODUCT OF BUTADIENE MANUFACTURE
0592-03	Y	1	.	.	BUTANE (ALL FORMS)/NAPHTHA CATALYTIC REFORMING
0592-04	3	.	.	.	BUTANE (ALL FORMS)/REFINERY BY-PRODUCT
0600-99	G	2	1	.	N-BUTYLACETATE/ BUTANOL + ACETIC ANHYDRIDE

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                                   FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR    ZERO    UNK    PP_TEXT

0640-01       F1        1      .       .     N-BUTYL ALCOHOL/BY PRODUCT OF 1,3-BUTYLENE GLYCOL BY HYD
0640-02       F1        6      1       .     N-BUTYL ALCOHOL/HYDROGENATION OF N-BUTYRALDEHYDE, OXO PR
0640-05       12        1      .       .     N-BUTYL ALCOHOL/DISTILLATION OF DILUTE AQUEOUS BUTANOL
0650-01       12        3      .       .     SEC-BUTYL ALCOHOL/INDIRECT HYDRATION OF BUTENES
0660-99       12        1      .       .     TERT-BUTYL ALCOHOL/FROM ISOBUTYLENE
0710-01       F1        2      .       .     1,3 BUTYLENE GLYCOL/HYDROGENATION OF ACETALDOL
0720-01       15        5      2       .     BUTYLENES/BY EXTRACTIVE DISTILLATION OF C4 PYROLYZATES
0720-99       15        .      .       .     BUTYLENES/ FROM PYROLYZATE BY EXTRACTIVE DISTILLATION
0730-99       I         .      .       .     TERT-BUTYLPHENOL/ ALKYLATION OF PHENOL WITH ISOBUTYLENE
0750-01       O         2      1       .     N-BUTYRALDEHYDE/HYDROFORMYLATION OF PROPYLENE,OXO PROCES
0760-01       C         1      .       .     N-BUTYRIC ACID/OXIDATION OF BUTYRALDEHYDE
0760-02       C         .      1       .     N-BUTYRIC ACID/CO-PRODUCT OF BUTANE OXIDATION
0780-99       6         1      .       .     N-BUTYRONITRILE/ BUTANOL + NH3, DEHYDRATION
0785-00       4         .      .       .     CAPROLACTAM/
0785-06       Z         .      .       .     CAPROLACTAM/FROM PHENOL VIA CYCLOHEXANONE OXIME/
0785-07       Z         .      .       .     CAPROLACTAM/DEPOLYMERIZATION NYLON 6
0785-09       C         2      .       .     CAPROLACTAM/FROM CYCLOHEXANE VIA CYCLOHEXANONE AND OXIME
0790-99       3         1      .       .     CARBON DISULFIDE/PROCESS UNDER REVIEW
0810-01       B         2      .       .     CARBON TETRACHLORIDE/CHLORINATION OF METHANE
0810-02       B         3      2       .     CARBON TETRACHLORIDE/CHLOR. OF METHYL CHLORIDE (FROM HYDROCHLORINATION OF METHANOL)
0810-03       B         .      .       .     CARBON TETRACHLORIDE/CHLORINATION OF CARBON DISULFIDE
0810-04       B         4      2       .     CARBON TETRACHLORIDE/CO-PRODUCTION OF TETRACHLOROETHYLEN
0810-05       B         1      .       .     CARBON TETRACHLORIDE/BY-PRODUCT OF PHOSGENE MANUFACTURE
0814-01       D1        .      .       .     CARBOXMETHYL CELLULOSE/ETHERIFICATION OF CELLULOSE
0815-00       E         .      .       .     CASTOR OIL (INCLUDING USP)/
0815-99       4         .      .       .     CASTOR OIL (INCLUDING USP)  PROCESS UNDER REVIEW
0816-01       G         3      .       .     CELLOPHANE/VISCOSE PROCESS
0820-01       23        5      .       .     CELLULOSE ACETATES FIBERS/SPINNING FROM ACETYLATED CELLU
0820-03       D1        5      .       .     CELLULOSE ACETATES RESIN/ACETYLATION OF CELLULOSE
0821-01       O         1      .       .     CELLULOSE ACETATE/BUTYRATES
0823-01       O         1      .       .     CELLULOSE ACETATES/PROPIONATES/ESTERIFICATN OF CELLULOSE
0824-01       L         1      .       .     CELLULOSE NITRATE/NITRATION OF CELLULOSE
0825-01       G         1      .       .     CELLULOSE SPONGE/VISCOSE PROCESS
0840-99       B         .      .       .     CHLOROACETIC ACID/ CHLORINATION OF ACETIC ACID
0890-01       B         2      .       .     CHLOROBENZENE/CHLORINATION OF BENZENE
0890-99       4         .      .       .     CHLOROBENZENE/
0921-01       P         1      .       .     CHLORODIFLUOROMETHANE/HYDROFLUORINATION OF CHLOROFORM
0930-01       B         3      2       .     CHLOROFORM/CHLORINATION OF METHYLCHLORIDE (FROM HYDROCHLORINATION OF METHANOL)
0930-02       B         2      .       .     CHLOROFORM/CHLORINATION OF METHANE
0930-03       B         .      .       .     CHLOROFORM/BY-PRODUCT OF CARBON TETRACHLORIDE PRODUCTION
0930-04       C         1      .       .     CHLOROFORM/ BY-PRODUCT OF ACETALDEHYDE PRODUCTION
0949-01       B         1      .       .     M-CHLORONITROBENZENE/CHLORINATION OF NITROBENZENE
0950-99       L         .      .       .     O-CHLORONITROBENZENE/  NITRATION OF CHLOROBENZENE
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                                    FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR    ZERO    UNK    PP_TEXT

0951-99       L          1      .       .    P-CHLORONITROBENZENE/ NITRATION OF CHLOROBENZENE
0961-01       B          1      .       .    2-CHLOROPHENOL/CHLORINATION OF PHENOL
0963-01       B          1      .       .    4-CHLOROPHENYL PHENYL ETHER/CHLOR OF PHENYL PHENYL ETHER
0993-00       6          .      .       .    CHOLINE CHLORIDE/ ETHYLENE OXIDE + TRIMETHYLAMINE + HCL
0993-01       6          1      .       .    CHOLINE CHLORIDE/ ETHYLENE CHLOROHYDRIN + TRIMETHYL AMINE
0993-99       4          .      .       .    CHOLINE CHLORIDE/PROCESS UNDER REVIEW
0994-99       3          .      .       .    CHROMIUM(TOTAL)/PROCESS UNDER REVIEW
0997-01       H          .      1       .    COAL TAR/COKING  OF COAL
0998-99       3          1      .       .    COPPER (TOTAL)-PROCESS UNDER REVIEW
1005-01       2          2      1       .    COAL TAR PRODUCTS (MISC.)/COAL TAR DISTILLATION
1007-01       H          .      .       .    CREOSOTE/DIST. OF COAL TAR LIGHT OIL
1010-01       H          .      .       .    O-CRESOL/REFINING OF MIXED CRESOLS
1021-01       2          .      1       .    CRESOLS,MIXED/TAR ACID RECOVERY AND REFINING
1030-01       2          .      1       .    CRESYLIC ACID/TAR ACID RECOVERY REFINING
1060-01       I2         2      .       .    CUMENE/ALKYLATION OF BENZENE BY PROPYLENE
1080-99       7          1      .       .    CYANOACETIC ACID/ CHLOROACETIC ACID + NACN
1100-99       3          .      .       .    CYANURIC ACID/ HEAT UREA
1120-02       F2         2      .       .    CYCLOHEXANE/HYDROGENATION OF BENZENE
1122-01       F2         1      .       .    CYCLOHEXANE DIMETHANOL/HYDROGENATION OF DIMETHYL TERAPHT
1130-02       F2         .      .       .    CYCLOHEXANOL/HYDROGENATION OF PHENOL-DISTIL
1135-01       C          1      2       .    CYCLOHEXANOL/ONE(MIXED)/OXIDATION OF CCYCLOHEXANE
1140-01       C          .      1       .    CYCLOHEXANONE/OXIDATION OF CYCLOHEXANE
1140-02       F2         .      .       .    CYCLOHEXANONE/HYDROGENATION OF PHENOL-DISTIL
1140-03       C          1      .       .    CYCLOHEXANONE/OXID OF CYCLOHEXANE-DISTIL-DEHYDROG OF OL
1140-04       J1         1      .       .    CYCLOHEXANONE/DEHYDROGENATION OF CYCLOHEXANOL
1170-99       D2         1      .       .    CYCLOOCTADIENE/ DIMERIZATION OF BUTADIENE (NICKLE CAT.)
1171-01       15         2      .       .    CYCLOPENTADIENE DIMER/EXTR DIST C5 PYROLYZATES + DIMERIZ
1190-01       A          2      .       .    DIACETONE ALCOHOL/ALDOL CONDENSATION OF ACETONE
1215-01       B          1      .       .    M-DICHLOROBENZENE/CHLORINATION OF BENZENE
1216-01       B          2      .       .    O-DICHLOROBENZENE/CHLORINATION OF BENZENE
1216-02       V          1      .       .    O-DICHLOROBENZENE/BY-PRODUCT OF POLYMERIC MDI OR TDI MANUFACTURE (PHOSGENATION SOLVENT)
1220-01       B          3      .       .    P-DICHLOROBENZENE/CHLORINATION OF BENZENE
1221-01       P          4      1       .    DICHLORODIFLUOROMETHANE/HYDROFLUORINATION OF CARBON TETRACHLD
1225-02       P          1      .       .    1,1 DICHLOROETHANE/REACT OF HCL & VINYL CHLORIDE
1236-00       B          1      .       .    1,2-TRANS-DICHLOROETHYLENE/ CHLORINATION OF ETHYLENE
1244-01       B         10      1       .    1,2-DICHLOROETHANE/DIRECT CHLORINATION OF ETHYLENE
1244-02       B          1      .       .    1,2 DICHLOROETHANE/ CHLORINATION OF ETHYLENE
1244-03       S          6      .       .    1,2-DICHLOROETHANE/OXYCHLORINATION OF ETHYLENE
1257-01       B          1      .       .    DICHLORONITROBENZENE/CHLORINATION OF NITROBENZENE
1265-01       B          1      .       .    2,4-DICHLOROPHENOL/CHLORINATION OF PHENOL
1271-01       B          .      .       .    1,2-DICHLOROPROPENE/BY-PDCT OF ALLYL CHLORIDE MANUFACTUR
1281-99       20         1      .       .    DICHLOROPROPANE/ BY PRODUCT CHLOROHYDRINATION OF PROPYLENE
1300-01       5          9      1       .    DIETHYLENE GLYCOL/COPRODUCT OF ETHYLENE GLYCOL FROM ETHY
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FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
1300-04	5	.	2	.	DIETHYLENE GLYCOL (REFINING OF DISTIL TAILS) / ETHYLENE GLYCOL + E.O.
1300-05	E	.	.	.	DIETHYLENE GLYCOL/CO-PROD OF HYDROLYSIS -ETHYLENE OXIDE
1365-01	6	.	1	.	DIETHYLENE TRIAMINE/ETHYLENE DIAMINE + EDC + NH3
1440-99	D2	1	.	.	DIISOBUTYLENE/PROCESS UNDER REVIEW
1442-01	I2	1	.	.	DIISOPROPYL BENZENE/BY-PROD OF CUMENE
1450-01	A	2	.	.	DIKETENE/DIMERIZATION OF KETENE-ACETIC ACID
1465-99	5	.	.	.	2-DIMETHYLAMINOETHANOL/ ETHOXYLATION OF DIMETHYLAMINE
1470-01	A	.	.	.	N,N-DIMETHYLANILINE/CATALYTIC CONDENSATION OF ANILINE
1480-99	A	1	.	.	DIMETHYL ETHER/DEHYDRATION OF METHANOL
1490-00	K	1	.	.	N,N-DIMETHYLFORMAMIDE/ DIMETHYLAMINE + FORMALDEHYDE
1490-99	K	1	.	.	N,N-DIMETHYLFORMAMIDE/ DIMETHYLAMINE + FORMIC ACID
1500-99	G	1	.	.	DIMETHYL SULFATE/ METHANOL + SULFURIC ACID
1510-99	14	1	.	.	METHYL SULFIDE/ K METHYL SULFATE +K2S
1530-01	G	5	.	.	DIMETHYL TEREPHTHALATE/ESTERIFICATION OF TPA+METHANOL
1530-02	C	2	.	.	DIMETHYL TEREPHTHALATE/OXIDATION OF P-XYLENE METHYL ESTE
1535-99	L	1	.	.	DINITROBENZENE(M,O,P)/ NITRATION OF BENZENE
1550-01	L	4	.	.	DINITROTOLUENE (MIXED)/NITRATION OF TOLUENE
1551-01	L	1	.	.	2,4 DINITROTOLUENE/NITRATION OF TOLUENE
1552-01	L	1	.	.	2,6 DINITROTOLUENE/NITRATION OF TOLUENE
1580-01	A	1	.	.	DIPHENYLAMINE/CATALYTIC CONDENSATION OF ANILINE
1590-99	A	.	1	.	DIPHENYL ETHER /CHLOROBENZENE + SODIUM PHENOLATE
1610-01	5	2	.	.	DIPROPYLENE GLYCOL/RXN OF PROP. GLYCOL + PROPY OXIDE
1610-02	E	.	.	.	DIPROPYLENE GLYCOL/CO-PROD OF HYDROLYSIS-PROPYLENE OXIDE
1612-99	A	.	.	.	2,2-DITHIOBISBENZOTHIAZOLE/ OXIDATION OF 2-MERCAPTOBENZOTRIAZOLE
1634-01	A	.	.	.	DODECYLGUANIDINE ACETATE/CONDENSATION OF DODECYLAMINE AC
1635-99	M	1	1	.	DODECYLMERCAPTAN/ DODECENE + H2S
1641-99	L	1	.	.	DYES&DYE INTERMEDIATES/VAT DYES, AZO DYES
1650-01	20	3	.	.	EPICHLOROHYDRIN/FROM ALLYL CHLORIDE VIA DICHLOROHYDRIN
1653-01	21	2	2	.	EPOXIDIZED ESTERS,TOTAL/EPOXIDATION OF UNSATURATED ESTER
1656-00	D1	.	.	.	EPOXY RESINS/ EPICHLOROHYDRIN + BISPHENOLA
1656-01	D1	3	3	.	EPOXY RESINS/EPICHLOROHYDRIN + BISPHENOL A
1656-02	D1	1	1	.	EPOXY RESINS/FROM POLYOLS + EPICHLOROHYDRIN
1656-03	D1	1	.	.	EPOXY RESINS/EPICHLOROHYDRIN AND NOVOLAK RESINS
1656-04	D	.	.	.	EPOXY RESINS/EPOXIDATION OF POLYMERS
1656-07	D1	.	.	.	EPOXY RESINS/PURCHSD EPOXY(EPI-BIS)RESIN + BISPHENOL A
1656-08	D1	1	.	.	EPOXY RESINS/PURCHSD EPXY RESINS,BISPHENOL A,FATTY ACID
1656-09	D1	1	.	.	EPOXY RESINS/MODIFIED EPOXYESTER
1656-10	D1	.	1	.	EPOXY RESINS/PURCHASED EPOXY(EPI-BIS)RESIN+DIETHANOLAMIN
1659-01	H	1	.	.	ETHANE/CRACKING OF NAPHTA
1659-02	2	1	.	.	ETHANE / NATURAL GAS BY-PRODUCT
1659-03	3	.	.	.	ETHANE/REFINERY BY-PRODUCT
1660-01	12	3	2	.	ETHANOL/DIRECT HYDRATION OF ETHYLENE
1660-02	C	.	1	.	ETHANOL/COPRODUCT OF BUTANE OXIDATION

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                              FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE   GEN_CODE   DIR   ZERO   UNK   PP_TEXT

1661-01     K          4     .     .    ETHANOLAMINES/AMMINOLYSIS OF ETHYLENE OXIDE
1666-01     5          4     .     .    ETHOXYLATES/FROM ALKYLENE OXIDE AND ALKANOL
1666-02     5          2     .     .    ETHOXYLATES,(MISC)/ALKYLPHENOL-PHENOL & ETHYLENE OXIDE
1666-03     5          2     1     .    ETHOXYLATES/C11,C12-LINEAR ALCOHOLS AND ETHYLENE OXIDE
1670-01     G          1     2     .    ETHYL ACETATE/ESTERIF OF ACETIC ACID WITH ETHANOL
1670-02     C          .     1     .    ETHYL ACETATE/COPRODUCT OF BUTANE OXIDATION
1670-03     E          .     .     .    ETHYL ACETATE/FROM POLYVINYL ACETATE AND ETHANOL
1670-04     A          1     .     .    ETHYL ACETOACETATE/ ACETALDEHYDE CONDENSATION
1700-01     K          1     .     .    ETHYLAMINE /AMMONOLYSIS OF ETHANOL
1710-01     I2         5     .     .    ETHYLBENZENE/BENZENE ALKYLATION
1710-02     H          3     .     .    ETHYLBENZENE/SEPARATION FROM BTX EXTRACT
1710-03     I          1     1     .    ETHYLBENZENE / ALKYLATION OF BENZENE WITH ETHYLENE
1710-04     2          1     .     .    ETHYLBENZENE/DISTILLATION FROM COAL TAR
1730-01     14         1     .     .    ETHYL CELLULOSE/CELLULOSE + ETHYL CHLORIDE
1740-01     P          7     .     .    ETHYL CHLORIDE/HYDROCHLORINATION OF ETHYLENE
1760-99     G          1     .     .    ETHYLCYANOACETATE/ ETHANOL ESTER OF CYANOACETIC ACID
1770-01     H         11     4     .    ETHYLENE/PYROLYSIS OF ETHANE/PROPANE/BUTANE/LPG
1770-02     H          5     1     .    ETHYLENE/PYROLYSIS OF NAPHTHA AND-OR GAS OIL
1770-03     H          2     .     .    ETHYLENE/PYROLYSIS OF ETHANE
1770-04     H          2     .     .    ETHYLENE/PYROLYSIS OF NAPHTHA,PROPANE,ETHANE,BUTANE
1770-05     2          1     .     .    ETHYLENE/FRACTIONATION OF REFINERY LIGHT ENDS
1800-01     K          2     1     .    ETHYLENE DIAMINE/AMINATION OF ETHYLENE DICHLORIDE
1810-99     B          .     .     .    ETHYLENE DIBROMIDE/ ETHYLENE + BROMINEW
1830-01     E         11     1     .    ETHYLENE GLYCOL/HYDROLYSIS OF ETHYLENE OXIDE
1830-02     E          2     1     .    ETHYLENE GLYCOL/HYDROLYSIS OF ETHLENE OXIDE
1920-99     G          1     .     .    ETHYLENE GLYCOL MONOETHYL ETHER ACETATE ETHANOL + ETHYLENE OXIDE + ACETIC ANHYDRIDE
1930-01     A          .     .     .    ETHYLENE GLYCOL MONOMETHYL ETHER/ METHANOL + ETHYLENEOXIDE
1930-02     5          1     .     .    ETHYLENE GLYCOL MONOMETHYL ETHER/ETHOXYLATION OF ALCHOLS
1930-99     5          2     .     .    ETHYLENE GLYCOL MONOMETHYL ETHER/ METHANOL + ETHYLENE OXIDE
1940-99     G          1     .     .    ETHYLENE GLYCOL MONOMETHYL ETHER ACETATE/ METHANOL + E.O. + ACETIC ANHYDRIDE
1980-01     C         11     2     .    ETHYLENE OXIDE/DIRECT OXIDATION OF ETHYLENE
1980-02     R          1     .     .    ETHYLENE OXIDE/VIA ETHYLENE CHLOROHYDRIN PROCESS
1985-01     D2         8     1     .    POLYETHYLENE & POLYVINYL ACETATE COPOLYMERS/
1995-01     C          1     .     .    2 ETHYL HEXANOIC ACID/OXIDATION OF 2-ETHYLHEXALDEHYDE (FROM ALDOL COND OF N-BUTYRALDEHYDE)
1995-02     C          .     .     .    2-ETHYLHEXANOIC ACID/OXIDATION OF 2-ETHYLHEXALDEHYDE
2000-01     A          4     .     .    2-ETHYL HEXANOL/ALDOL CONDENSATION-HYDROG OF N-BUTALDEHY
2010-99     14         1     .     .    ETHYL ORTHOFORMATE/ CHLOROFORM + NAETHANOLATE
2035-01     D2         3     .     .    FLUOROCARBON RESINS/POLYMERIZATION OF FLUORINATED OLEFINS
2040-01     C         11     9     .    FORMALDEHYDE/OXIDATION OF METHANOL-SILVER CATALYST
2040-03     C          7     9     .    FORMALDEHYDE/OXIDATION OF METHANOL-METAL OXIDE PROCESS
2050-99     K          1     .     .    FORMAMIDE/ FORMIC ACID + AMMONIA
2060-01     C          .     2     .    FORMIC ACID/BY-PRODUCT OF BUTANE OXIDATION
2060-02     3          .     .     .    FORMIC ACID/RECOVERY FROM SULFITE PULP WASTEWATER
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                                   FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR    ZERO    UNK    PP_TEXT

2070-01      22         1      .       .     FUMARIC ACID/ISOMERIZATION OF MALEIC ACID
2080-00      24         .      .       .     GLUTAMIC ACID, MONOSODIUM SALT/
2080-01      24         .      .       .     GLUTAMIC ACID, MONOSODIUM SALT/GLUTAMIC ACID + NAOH
2080-99      1          .      .       .     GLUTAMIC ACID, MONOSODIUM SALT/NEUT OF GLUT ACID BY NAOH
2090-01      12         1      .       .     GLYCERINE (SYNTHETIC)/HYDROXYLATION OF ALLYL ALCOHOL
2090-03      E          2      .       .     GLYCERINE(SYN)/HYDROL OF EPICHLOROHY VIA ALLYL CHLORIDE
2120-99      C          2      .       .     GLYOXAL/ OZONATION OF BENZENE
2136-01      H          .      .       .     HEPTANE/BTX SOLVENT EXTRACTION AND ADSORPTION
2145-01      B          .      1       .     HEXACHLOROBENZENE/CHLORINATION OF BENZENE
2145-02      A          1      .       .     HEXACHLOROBENZENE/BY PRODUCT OF TETRACHLOROETHYLENE (CHLORINATION OF EDC)
2145-03      B          1      .       .     HEXACHLOROBENZENE/BY-PRODUCT OF CHLOROSILANES
2150-01      B          1      .       .     HEXACHLOROETHANE/ETHANE CHLORINATION
2165-01      K          .      1       .     HEXAMETHYLENEDIAMINE/AMMONOLYSIS OF 1-6 HEXANEDIOL
2165-02      F1         2      2       .     HEXAMETHYLENEDIAMINE/HYDROGENATION OF ADIPONITRILE
2165-03      E          1      .       .     HEXAMETHYLENEDIAMINE/DEPOLYMERIZATION OF NYLON 66
2166-99      A          1      .       .     HEXYLENE GLYCOL/ ALDOL CINDENSATION OF ACETONE
2170-99      F1         .      1       .     HEXAMETHYLENE GLYCOL(1,6-HEXANEDIOL)/
2180-99      A          .      2       .     HEXAMETHYLENETETRAMINE / FORMALDEHYDE + NH3
2181-01      H          .      .       .     HEXANE/BTX SOLVENT EXTRACTION AND ADSORPTION
2181-02      3          .      .       .     HEXANE / REFINERY BY-PRODUCT
2185-99      3          1      .       .     HYDRAZINE SOLUTIONS/PROCESS UNDER REVIEW
2190-99      3          1      2       .     HYDROGEN CYANIDE / PROCESS UNDER REVIEW
2200-01      C          1      .       .     HYDROQUINONE/OXIDATION OF ANILINE VIA QUINONE
2212-01      5          1      .       .     HYDROXYETHYL CELLULOSE/ETHOXYLATION OF ALKALI CELLULOSE
2215-99      3          1      .       .     HYDROXYLAMINE/PROCESS UNDER REVIEW
2216-01      D1         .      .       .     HYDROXYPROPYL CELLULOSE/ETHERIFICATION OF CELLULOSE
2225-99      A          .      1       .     IMINODI-ACETIC ACID/ NH3 + FORMALDEHYDE + NACN
2240-99      15         1      .       .     ISOAMYLENE / EXTRACTIVE DISTILLATION OF BTX RAFFINATE
2250-01      F1         5      1       .     ISOBUTANOL/HYDROG OF ISOBUTYRALDEHYDE-OXO PROCESS
2250-02      A          .      1       .     ISOBUTANOL/FROM ISO-BUTYRALDEHYDE BY ALDOL CONDENSATION
2250-03      A          1      .       .     ISOBUTANOL/ CRUDE ISOBUTANOL BY ALDOL CONDENSATION/ HYDR
2260-99      G          1      1       .     ISOBUTYL ACETATE/ISOBUTANOL + ACETIC ANHYDRIDE
2265-01      15         2      .       .     ISOBUTYLENE/EXTRACT FROM C4 PYROLYZATE
2265-02      Q          1      .       .     ISOBUTYLENE/DEHYDRATION OF PURCHASED TERT-BUTANOL
2266-01      D2         1      .       .     ISOBUTYLENE POLYMERS/POLYMERIZATION OF ISOBUTYLENE
2270-01      O          2      1       .     ISOBUTYRALDEHYDE/HYDROFORMYLATION OF PROPYLENE-OXO PROCE
2280-01      C          1      .       .     ISOBUTYRIC ACID/ AIR OXIDATION OF ISOBUTYRALDEHYDE
2300-99      O          1      .       .     ISODECANOL/ CARBONYLATION OF OLEFIN OLIGOMERS +  H2
2320-99      O          1      .       .     ISOOCTYL ALCOHOL/CARBONYLATION OF OLEFIN OLIGOMERS + H2
2321-99      2          .      .       .     ISOPENTANE/ DISTILLATION FROM C4/C5 HYDROCARBON MIX
2330-01      A          1      .       .     ISOPHORONE/CATALYTIC GAS PHASE RXN OF ACETONE
2340-99      C          1      .       .     ISOPHTHALIC ACID/ OXIDATION OF M-XYLENE
2350-02      15         2      .       .     ISOPRENE/EXTRACTIVE DIST C5 PYROLYZATE
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                                    FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR    ZERO    UNK    PP_TEXT

2360-01     12          3      1       .     ISOPROPANOL/HYDRATIONS OF PROPYLENE
2360-02     F1          1      .       .     ISOPROPANOL/CATALYTIC HYDROGENATION OF ACETONE
2360-03     12          1      .       .     ISOPROPANOL/SOLVENT-WATER AZEOTROPIC DISTILLATION
2370-99     G           .      1       .     ISOPROPYL ACETATE/ISOPROPANOL + ACETIC ANHYDRIDE
2415-99     3           .      .       .     LEAD(TOTAL)/PROCESS UNDER REVIEW
2420-00     12          .      .       .     MALIC ACID/ HYDRATION OF MALEIC ACID
2430-01     C           3      .       .     MALEIC ANHYDRIDE/BENZENE OXIDATION
2430-02     C           .      .       .     MALEIC ANHYDRIDE/BY-PRODUCT OF PHTHALIC ANHYDRIDE BY OXI
2441-01     A           1      .       .     MELAMINE/TRIMERIZATION OF UREA
2442-99     3           .      .       .     MELAMINE CRYSTAL/ CONDENSATION OF UREA
2443-01     D1          7      3       .     MELAMINE RESINS/POLYCONDENSATION OF MELAMINE WITH FORMAL
2450-01     A           1      .       .     MESITYL OXIDE/DEHYDRATION OF DIACETONE ALCOHOL
2455-99     F2          .      .       .     METANILIC ACID/ HYDROGENATION OF 3-NITROBENZENE SULFONIC ACID
2460-01     18          2      .       .     METHACRYLIC ACID/ACETONE CYANOHYDRIN PROCESS
2470-02     G           2      .       .     METHACRYLIC ACID ESTERS/BUTYLMETHACRYLATES-ESTERIFIC OFM
2470-03     G           1      .       .     METHACRYLIC ACID ESTERS/ETHYL METHACRYLATE BY METHACRT A
2470-04     G           1      .       .     METHACRYLIC ACID ESTERS/2-ETHYL HEXYL METHACRLTE BY MEA
2470-05     G           1      .       .     METHACRYLIC ACID ESTERS/HIGHER METHACRYLATES BY METH ACI
2470-06     G           1      .       .     METHACRYLIC ACID ESTER/2-ACETOACETOXYETHL METHACRLTE FRM
2470-07     G           1      .       .     METHACRYLIC ACID ESTER/METHACRYLIC ACID ESTERIFCTN OF NO
2470-08     G           1      .       .     METHACRYLIC ACID ESTERS/BUTYL METHACRYLATE BY ACN & MEOL
2500-01     O           5      2       .     METHANOL/H.P. SYNTHESIS FROM NAT GAS VIA SYN GAS
2500-02     O           2      .       .     METHANOL/L.P. SYTHESIS FROM NAT GAS VIA SYN GAS
2500-03     F1          .      1       .     METHANOL/HYDROGENATION OF CARBON MONOXIDE
2500-04     F1          1      .       .     METHANOL/HYDROGENATION OF BUTYNEDIOL
2500-06     F           .      .       .     METHANOL/CATALYTIC HYDROGENATION OF ALDEHYDES
2500-07     D1          .      1       .     METHANOL/BY PRODUCT POLYESTER
2500-09     C           .      1       .     METHANOL/BUTANE OXIDATION
2500-10     Z           1      .       .     METHANOL/BY-PRODUCT OF ALKYLOLAMIDES
2530-00     6           .      .       .     METHYLAMINES/ METHANOL + AMMONIA
2530-01     K           3      .       .     METHYLAMINES(TOTAL)/CONDENSATION OF METHANOL AND AMMONIA
2545-01     P           1      .       .     METHYL BROMIDE/HYDROHALOGENATION OF METHANOL
2555-01     14          2      .       .     METHYL CELLULOSE/CELLULOSE + METHYL CHLORIDE
2560-00     16          .      1       .     METHYL CHLORIDE/ PROBABLY USED AS SOLBENT
2560-01     P           7      .       .     METHYL CHLORIDE/HYDROCHLORINATION OF METHANOL
2560-03     B           1      .       .     METHYL CHLORIDE/CHLORINATION OF METHANE
2560-05     C           1      .       .     METHYL CHLORIDE /BYPRODUCT OF ETHYLENE OXIDE 1980-01
2620-01     B           3      2       .     METHYLENE CHLORIDE/CHLORINATION OF MET HYLCHLORIDE (FROM HYDROCHLORINATION OF METHANOL)
2620-02     B           1      .       .     METHYLENE CHLORIDE/CHLORINATION OF METHANE
2620-03     C           1      .       .     METHYLENE CHLORIDE/ BY-PRODUCT ETHYENE OXIDE 1980-01
2630-01     A           1      .       .     METHYLENE DIANILINE/REACTION OF FORMALDEHYDE +ANILINE
2631-00     A           .      .       .     4,4'-METHYLENEDIANILINE/ (MDI) ANILINE + FORMALDEHYDE
2635-01     V           2      .       .     METHYLENE DIPHENYL DIISOCYANATE/PHOSGENATION OF MDA
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                              FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE   DIR   ZERO   UNK   PP_TEXT

2640-01       J1       2     .      .    METHYL ETHYL KETONE/DEHYDROGENATION OF SEC-BUTANOL
2640-06       C        .     2      .    METHYL ETHYL KETONE/BY-PRODUCT OF BUTANE OXIDATION
2640-07       J1       1     .      .    METHYL ETHYL KETONE/REDOX,OF ACROLEIN & SEC-BUTANOL
2640-08       J1       1     .      .    METHYL ETHYL KETONE/ DEHYDROGENATION OF SEC-BUTANOL
2645-99       G        1     1      .    METHYL FORMATE/ FORMALDEHYDE + CAUSTIC (CANNIZARO)
2650-99       A        1     .      .    METHYL ISOBUTYL CARBINOL / ALDOL CINDENSATION OF ACETONE
2660-01       F1       3     .      .    METHYL ISOBUTYL KETONE/HYDROGENATION OF MESITYL OXIDE
2665-02       G        3     .      .    METHYL METHACRYLATE/METHANOLYSIS OF ACETONE CYANOHYDRIN
2665-03       G        .     .      .    METHYL METHACRYLATE/METHACRYLIC ACID + METHANOL
2665-04       H        .     .      .    METHYL METHACRYLATE/POLYMER CRACKING
2680-01       G        .     .      .    METHYL SALICYLATE/ESTERIFICATION OF SALICYLIC ACID
2690-01       C        3     .      .    A-METHYLSTYRENE/BY-PROD OF ACETONE&PHENOL BY CUMENE OXID
2690-02       J2       .     .      .    ALPHA-METHYLSTYRENE/DEHYDROGENATION OF CUMENE
2691-01       D1       1     .      .    MODACRYLIC RESIN/RESIN-POLYACRYLONITRILE & COMONOMER
2691-07       D        .     .      .    MODACRYLIC RESIN/RESIN-POLYACRYLONITRILE & COMONOMER
2691-11       D1       1     .      .    MODACRYLIC RESIN/FIBER-POLYACRYLONITRILE & COMONOMER
2695-99       6        .     .      .    2-(MORPHOLINO-THIO)-BENZOTHIAZOLE/ MORPHOLNE + 2-MERCAPTOBENZOTHIAZOLE
2701-01       2        1     .      .    NAPHTHALENE/SEPARATION FROM COAL TAR DISTILLATE
2701-02       2        2     .      .    NAPHTHALENE/DISTILLATION FROM PYROLYSIS GAS
2750-01       O        1     .      .    NEOPENTANOIC ACID/FROM ISOBUTYLENE VIA OXO PROCESS AND OXIDATION
2756-01       K        1     .      .    P-NITROANILINE/AMMONOLYSIS OF PARA-NITROCHLOROBENZENE
2757-01       K        1     .      .    P-NITROANILINE/AMMONOLYSIS OF PARA-NITROCHLOROBENZENE
2770-01       L        4     .      .    NITROBENZENE/NITRATION OF BENZENE
2770-10       4        .     .      .    NITROBENZENE/
2792-00       L        1     .      .    2-NITROPHENOL/ NITRATION OF PHENOL
2792-99       4        .     .      .    2-NITROPHENOL/PROCESS UNDER REVIEW
2793-99       L        1     .      .    P-NITROPHENOL & SODIUM SALT/ NITRATION OF PHENOL
2800-01       L        2     .      .    NITROTOLUENE/NITRATION OF TOLUENE
2805-99       C        .     .      .    N-NITROSODIPHENYLAMINE/ DIPHENYLAMINE + NITROUS OXIDE
2824-01       Z        .     .      .    NYLON SALT/ADIPIC ACID & HMDA-AQUEOUS SOLUTION
2824-02       Z        .     1      .    NYLON SALT/ADIPIC ACID & HMDA-METHANOL SOLUTION
2825-00       4        .     .      .    NYLON/
2825-01       D1       5     2      .    NYLON 6/RESIN BY POLYCONDENSATION FROM CAPROLACTAM
2825-02       D1       7     1      .    NYLON 6/FIBER BY POLYCONDENSATION FROM CAPROLACTAM
2825-03       D1       2     1      .    NYLON 66/RESIN BY POLYCONDENSATION FROM NYLON SALT
2825-04       D1       9     1      .    NYLON 66/FIBER BY POLYCONDENSATION FROM NYLON SALT
2825-05       D1       1     .      .    NYLON 612/RESIN- POLYCONDENSATION FROM HMDA & CISDIACIDS
2825-08       D1       1     .      .    NYLON 6 & 66 COPOLY/POLYCOND OF NYLON SALT & CAPROLACTAM
2825-09       D1       1     .      .    NYLON/MISCELLANEOUS NYLON PRODUCTS-RESINS
2825-10       D1       1     .      .    NYLON/NYLON FORMALDEHYDE RESIN
2825-11       D1       .     .      .    NYLON COATING SOLUTION/
2825-22       23       1     .      .    NYLON 6 FIBER/EXTRUSION
2825-90       23       3     1      .    NYLON/NYLON FINISHING PROCESSES
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                          FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS
PP_CODE   GEN_CODE   DIR   ZERO   UNK   PP_TEXT

2831-01   O            4     .     .    OXO ALDEHYDES-ALCOHOLS/MISC ALDEHYDES
2831-02   O            .     1     .    OXO ALDEHYDES-ALCOHOLS/AMYL ALCOHOL
2831-05   O            .     1     .    OXO ALDEHYDES-ALCOHOLS/C11-C14 ALC FROM C10-C-C13 OLEFIN
2831-07   O            1     .     .    OXO ALDEHYDES/ALCOHOLS/NEOPENTANOL FROM ISOBUTYLENE
2831-08   O            .     1     .    OXO ALDEHYDES-ALCOHOLS/AMYL ALDEHYDE(MIXED)
2832-01   H            .     .     .    OCTANE/BTX SOLVENT EXTRACTION AND ADSORPTION
2841-01   B            1     .     .    PENTACHLOROBENZENE/BY-PRODUCT OF BENZENE CHLORINATION
2843-01   B            1     .     .    PENTACHLOROPHENOL/CHLORINATION OF PHENOL
2843-99   B            .     1     .    PENTACHLOROPHENOL/ CHLORINATION OF PHENOL
2850-01   A            3     .     .    PENTAERYTHRITOL/ALDOL COND.OF ACETALDEHYDE & FORMALDEHYD
2853-01   3            .     .     .    PENTANE/REFINERY BY-PRODUCT
2856-01   D2           3     1     .    PETROLEUM HYDROCARBON RESINS/FROM C5-C8 UNSATURATES
2857-01   C            1     .     .    PERACETIC ACID/PEROXIDATION OF ACETALDEHYDE
2858-01   G            2     2     .    PHTHALIC ESTER/PHTHALIC ACID AND ALCOHOL ESTERIFICATION
2859-01   G            2     .     .    BIS 2-ETHYLHEXYL PHTHALATE ESTER/2960 & ALCOHOL ESTERIFI
2860-01   G            .     .     .    BUTYLOCTYL PHTHALATE ESTER/2960 & ALCOHOL ESTERIFICATION
2862-01   G            .     .     .    C7-C10 PHTHALATE ESTER/2960 AND ALCOHOL ESTERIFICATION
2863-01   G            1     .     .    C11-C14 PHTHALATE ESTER/2960 & ALCOHOL ESTERIFICATION
2865-01   G            2     .     .    DIBUTYL PHTHALATE ESTER/2960 + ALCOHOL ESTERIFICATION
2867-01   G            .     .     .    DI-DECYL PHTHALATE ESTER/2960 AND ALCOHOL ESTERIFICATION
2868-01   G            .     .     .    DI-N-HEXYL PHTHALATE ESTER/2960 AND ALCOHOL ESTERIFICATI
2870-01   G            1     .     .    DI-ISODECYL PHTHALATE ESTER/2960 & ALCOHOL ESTERIFICATIO
2871-01   G            1     .     .    DI-ISOOCTYL PHTHALATE ESTER/2960 & ALCOHOL ESTERIFICATIO
2872-01   G            .     .     .    DIPHENYL PHTHALATE ESTER/PHENOL&PHTHALYL CHLORIDE ESTERI
2873-01   G            1     .     .    DI-TRIDECYL PHTHALATE ESTER/2960 & ALCOHOL ESTERIFICATIO
2874-01   G            1     .     .    N-HEPTYLNONYLUNDECYL PHTHALATE ESTER/2960 & ALCOHOL ESTE
2875-01   G            1     .     .    N-HEXYL-2-ETHYLHEXYLISODECYL PHTHALATE ESTER/2960 & ALCO
2876-01   G            1     .     .    N-HEXYL-2-ETHYLHEXYL PHATHALATE/2960 & ALCOHOL ESTERIFIC
2877-01   G            1     .     .    N-HEXYLHEPTYLNONYLUNDECYL PHTHALATE ESTER/2960 & ALCOHOL
2878-01   G            1     .     .    N-HEXYLOCTYLDECYL PHTHALATE ESTER/2960 & ALCOHOL ESTERIF
2879-01   G            1     .     .    MIXED ALCOHOL PHTHALATE ESTER/2960 & ALCOHOL ESTERFICATI
2880-01   G            .     .     .    OCTYLDECYL PHTHALATE ESTER/2950 & ALCOHOL ESTERIFICATION
2883-01   G            2     .     .    DI-ETHYL PHTHALATE ESTER/2960 AND ALCOHOL ESTERIFICATION
2884-01   G            .     .     .    DI-N-OCTYL PHTHALATE ESTER/2960 AND ALCOHOL ESTERIFICATI
2885-01   G            3     .     .    DIMETHYL PHTHALATE ESTER/2960 AND ALCOHOL ESTERIFICATION
2886-01   G            1     .     .    BUTYLBENZYL PHTIHALATE ESTER/2960 + BUTANOL + BENZYL ICORIDE
2905-01   D1          14    24     .    PHENOLIC RESINS/POLYCONDENSATION OF PHENOL WITH FORMALDEHYDE
2910-02   C            6     .     .    PHENOL/CUMENE PEROXIDATION AND ACID CLEAVAGE
2910-03   C            1     .     .    PHENOL/OXIDATION OF TOLUENE
2910-05   M            1     .     .    PHENOL/BENZENE SULFONATION,HYDROLYSIS
2910-08   C            1     .     .    PHENOL/LIQUID PHASE OXIDATION OF BENZOIC ACID
2910-09   16           .     1     .    PHENOL/TAR ACID RECOVERY REFINING
2910-10   16           1     .     .    PHENOL/RECOVERY FROM PYROLYSIS GASOLINE
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FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
2910-12	4	1	.	.	PHENOL/BY-PRODUCT OF DIPHENYL OXIDE
2910-13	L	1	.	.	PHENOL/BY-PRODUCT OF ISOCYANATES (FROM NITORENZENE AND DINITROTOLUENE PRCURSORS)
2950-00	3	.	.	.	PHOSGENE/ CHLORINE + CARBON MONOXIDE
2950-01	R	6	.	.	PHOSGENE/CHLORINATION OF CARBON MONOXIDE
2951-01	G	1	.	.	PHOSPHATE ESTHERS/PHOSPHORUS OXYCHLORIDE AND PHENOL/ALC
2951-02	G	1	.	.	PHOSPHATE ESTERS /DIPHENYLISODECYL - POCL3&PHENOL&ISODEC
2960-01	C	1	.	.	PHTHALIC ANHYDRIDE/OXIDATION OF NAPHTHALENE
2960-02	C	2	.	.	PHTHALIC ANHYDRIDE/OXIDATION OF O-XYLENE
2981-01	H	.	.	.	PITCH TAR RESIDUE/SEP.FROM COAL TAR LIGHT OIL DISTILLATE
2990-99	D1	1	.	.	POLYCETAL RESINS/PROCESS UNDER REVIEW
2992-99	D2	.	.	.	POLY-ALPHA-METHYL STYRENE/PROCESS UNDER REVIEW
2996-01	D1	.	.	1	POLYAMIDES FROM ETHYLENE AMINES AND FATTY ACIDS
2996-02	D1	.	.	.	NYLONS/FROM ADIPIC ACID,DIETHYLENETRIAMINE,EPICHLOROHYDR
2996-05	D1	.	1	.	POLYAMIDES-ALSO SEE NYLONS/FROM DIBASIC ACID AND AMINES
2996-99	D1	.	1	.	POLYAMIDES/ DICARBOXYLIC ACID + DIAMINE
3000-99	D2	.	1	.	POLYBUTENES/ SOLUTION POYMERIZATION OF BUTYLENES
3004-00	V	1	.	.	POLYCARBONATES/GENERAL
3004-99	V	2	.	.	POLYCARBONATES/PROCESS UNDER REVIEW
3006-05	3	.	.	.	POLYESTER/FIBER - MELT SPINNING FROM PURCHASED RESIN
3006-20	D1	2	.	.	POLYESTER/RESIN BY POLYCOND. FROM DMT & 1,4-CYCLOHEXANOL
3006-21	D1	6	2	.	POLYESTER/RESIN BY POLYCOND. FROM TPA & ETHYLENE GLYCOL
3006-22	D1	1	.	.	POLYESTER/RESIN BY POLYCOND. FROM PHTHALIC AND ANHYDR.
3006-23	D1	7	2	.	POLYESTER/RESIN BY POLYCOND. FROM DMT & ETHYLENE GLYCOL
3006-26	D1	1	.	.	POLYESTER/RESIN BY POLYCON. FROM TPA OR DMT & ETHYLGLYC.
3006-28	D1	2	.	.	POLYESTER/RESIN BY POLYCON. FROM DMT AND BUTANEDIOL
3006-29	D1	3	1	1	POLYESTER/RESIN BY POLYCOND. FROM VARIOUS ACID & ALC.
3006-30	D1	1	.	.	POLYESTER/FIBER BY MELT SPINNING FROM DMT AND 1,4
3006-31	D1	4	.	.	POLYESTER/FIBER BY MELT SPINNING FROM TPA AND ETHY GLYCL
3006-33	D1	10	.	.	POLYESTER/FIBER BY MELT SPINNING FROM DMT AND ETHY GLYCL
3006-34	D1	1	.	.	POLYESTER/FIBER BY MELT SPINNING FROM TPA OR DMT&ETHYGLY
3006-35	23	4	.	.	POLYESTER/FIBER BY MELT SPINNING FROM PURCHASED RESIN
3006-37	D1	1	.	.	POLYESTER/FIBER
3006-40	D1	1	.	.	POLYESTER/FILM FROM DMT AND 1,4 CYCLOHEXANE DIMETHANOL
3006-90	3	4	.	.	POLYESTER/FINISHING PROCESS
3006-99	D1	.	1	.	POLYESTER/
3008-01	D2	9	1	.	POLYETHYLENE RESINS/SOLUTION POLYMERIZATION(HDPE)
3008-03	D2	5	.	.	POLYETHYLENE RESIN/SUSPENSION POLYM(PARTICLE FORM)(HDPE)
3008-04	D2	15	3	.	POLYETHYLENE RESINS/HIGH PRESSURE POLYMERIZATION (LDPE)
3008-09	D2	2	.	.	POLYETHYLENE RESINS/GAS PHASE POLYMERIZATION (HDPE)
3008-90	3	1	.	.	POLYETHYLENE/FINISHING PROCESS
3008-99	D2	.	.	.	POLYETHYLENE/PROCESS UNDER REVIEW
3009-00	D2	2	.	.	POLYETHYLENE COPOLYMERS/
3010-00	5	1	.	.	POLYOXYETHYLENE GLYCOL/ETHOXYLATION OF ETHYLENE GLYCOL

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                                 FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE   GEN_CODE   DIR   ZERO   UNK   PP_TEXT

3010-01      5         2     .     .    POLYETHYLENE GYCOL/ ETHYLENE OXIDE
3011-01      6         2     .     .    POLYETHYLENE POLYAMINES/ETHYLENE DIAMINE + EDC + NH3
3013-01      D1        2     .     .    POLYMERIC METHYLENE DIANILINE/REACTION OF ANIL & FORMALH
3015-01      A         2     .     .    POLYMERIC METHYLENE DIPHENYL DIISOCYANATE/FROM POLY METH
3015-02      A         1     .     .    POLYMERIC METHYLENE DIPHENYL DIISOCYANATE/METHYLENE DIAN
3015-80      A         1     .     .    POLYMERIC METHYLENE DIPHENYL DIISOCYANATE/RXN OF FORM+AN
3020-01      23        3     .     .    POLYPROPYLENE /FIBER BY MELT SPINNING FROM PURCHAS RESIN
3020-03      D2        5     1     .    POLYPROPYLENE/RESIN BY SOLUTION POLYMERIZATION
3020-04      3         .     .     .    POLYPROPYLENE/POLYMER EXTRUSION
3020-05      D2        2     .     .    POLYPROPYLENE/RESIN BY SUSPENSION POLYMERIZATION
3020-06      D2        1     .     .    POLYPROPYLENE/GAS PHASE POLYMERIZATION
3020-90      3         .     .     .    POLYPROPYLENE/FINISHING PROCESS
3025-01      5         4     .     .    POLYOXYPROPYLENE GYCOL/ REACT OF PROPYLENE GYCOL & PROPYLENE OXIDE
3025-02      5         2     .     .    POLYOXYPROPYLENE GLYCOL/PROPOXYLATION OF GLYCERINE
3030-02      D1        5     .     .    POLYSTYRENE + COPOLYMERS/SUSP POLYMERIZATION W-O RUBBER
3030-03      D2        6     2     .    POLYSTYRENE & COPOLYMERS/HULK POLYMERIZATION WITH RUBBER
3030-04      D2        4     4     .    POLYSTYRENE + COPOLYMERS/BULK POLYMERIZATION W-O RUBBER
3030-06      D2        .     .     .    POLYSTYRENE AND COPOLYMERS/
3030-90      3         1     .     .    POLYSTYRENE + COPOLYMERS/FINISHING  PROCESS
3031-01      D2        .     1     .    POLYSTYRENE,EXPANDED/POLYMERIZATION OF POLYSTYRENE
3033-99      D1        1     .     .    POLYSULFONE RESINS/FROM SODIUM BISPHENOLATE
3036-00      D1        1     .     .    POLYURETHANE RFSINS/ POLYOLS + DIISOCYANATE
3036-01      D1        5    17     .    POLYURETHANE RESINS/ POLYOL + DIISOCYANATES
3036-02      3         .     1     .    POLYURETHANE RESINS/COMPOUNDING
3040-01      D1        6     2     .    POLYVINYL ACETATE RESINS/EMULSION POLYMERIZATION
3040-03      D1        1     .     .    POLYVINYL ACETATE RESINS/SOLUTION POLYMERIZATION
3042-01      E         2     .     .    POLYVINYL ALCOHOL/HYDROLYSIS OF POLYVINYL ACETATE
3042-08      D1        1     .     .    POLYVINYL ALCOHOL/RESIN-SOLUTION POLYM (METHANOL) OF VINYL ACETATE, HYDROLYSIS OF POLYMER
3042-80      D         .     .     .    POLYVINYL ALCOHOL/RESIN-SOLN POLYM(METHANOL)OF VINYLACET
3043-01      D1        1     2     .    POLYVINYLACETATE+ACRYLIC COPOLYMERS/LATEX-EMULSION POLYM
3044-03      D1        .     .     .    POLYVINYL RUTYRAL/POLYVINYL ACETATE AND BUTYRALDEHYDE
3044-99      D1        1     .     .    POLYVINYL BUTYRAL/PROCESS UNDER REVIEW
3045-01      D1        3     .     .    POLYVINYL ACETATE & PVC COPOLYMERS/SUSPEN POLYMERIZATION
3045-02      D1        .     1     .    POLYVINYL ACETATE & PVC COPOLYMERS/SOLUTION POLYMERIZATI
3045-03      D1        1     .     .    POLYVINYL ACETATE & PVC COPOLYMERS/EMULSION POLYMERIZATI
3045-04      D1        1     .     .    POLYVINYL ACETATE & PVC COPOLYMERS/STAPLE FIRER FROM RES
3047-01      D1        1     .     .    COPOLYMERS OF POLYVINYL ACETATE/EMULSION POLYMERIZATION
3047-02      D1        1     .     .    POLYVINYL ACETATE COPOLYMERS/SOLPOLY WT VIN PYROLLIDINON
3047-03      D1        1     .     .    COPOLYMERS OF POLYVINYL ACETATE/COPOLYMER WITH ETHYLENE
3048-01      D2        7     .     .    POLYVINYL CHLORIDE/EMULSION POLYMERIZATION
3048-02      D2       16     .     .    POLYVINYL CHLORIDE/SUSPENSION POLYMERIZATION
3048-04      D2        3     .     .    POLYVINYL CHLORIDE/BULK POLYMERIZATION
3048-11      3         .     .     .    POLYVINYL CHLORIDE/FILM OR FIBER BY CALENDERING
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FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
3048-90	3	4	.	.	POLYVINYL CHLORIDE/FINISHING PROCESS
3050-01	O	1	1	.	PROPIONALDEHYDE/HYDROFORMYLATION OF ETHYLENE-OXO PROCESS
3052-01	D2	1	.	.	POLYVINYL CHLORIDE COPOLYMERS/SUSPENSION POLYMERIZATION
3055-99	D1	1	.	.	POLYVINYL PYRROLIDONE/POLYMERIZATION OF VINYL PYRROLIDONE
3060-01	D2	.	1	.	POLYVINYLIDENE CHLORIDE/EMULSION POLYMERIZATION
3060-99	D2	1	.	.	POLYVINYLIDENE CHLORIDES/PROCESS UNDER REVIEW
3063-01	3	.	.	.	PROPANE/REFINERY BY-PRODUCT
3063-02	2	2	.	.	PROPANE/NATURAL GAS BY-PRODUCT
3063-03	H	.	.	.	PROPANE/BUTANE PYROLYSIS
3066-01	C	1	1	.	PROPIONIC ACID/AIR OXIDATION OF PROPIONALDEHYDE
3066-02	C	.	2	.	PROPIONIC ACID/CO-PRODUCT OF BUTANE OXIDATION
3066-04	C	.	1	.	PROPIONIC ACID/BY-PRODUCT OF NITROPARAFFINS
3068-01	G	1	1	.	N-PROPYL ACETATE/REACTION OF ACETIC ACID & N-PROPANOL
3070-01	F1	2	1	.	N-PROPYL ALCOHOL/HYDROGENATION OF PROPIONALDEHYDE-OXO PR
3090-02	H	10	3	.	PROPYLENE/PYROLYSIS OF ETHANE/PROPANE/BUTANE/LPG
3090-06	H	5	1	.	PROPYLENE/PYROLYSIS OF NAPHTHA AND OR GAS OIL
3090-08	2	1	.	.	PROPYLENE/FRACTIONATION OF REFINERY LIGHT ENDS
3090-11	H	2	.	.	PROPYLENE/PYROLYSIS OF NAPHTHA,PROPANE,ETHANE,BUTANE
3100-01	20	1	.	.	PROPYLENE CHLOROHYDRIN/INTERMEDIATE IN CHLOROHYDRIN PROC
3110-01	20	1	.	.	PROPYLENE DICHLORIDE/CHLOROHYDRINATION OF ALLYL CHLORIDE
3110-02	20	1	.	.	PROPYLENE DICHLORIDE/BY-PDCT OF PROPY OXIDE BY CHLOROHYD
3111-01	E	3	.	.	PROPYLENE GLYCOL/HYDROLYSIS OF PROPYLENE OXIDE
3120-02	R	3	.	.	PROPYLENE OXIDE/FROM PROPYLENE VIA CHLOROHYDRIN
3135-01	H	.	1	.	PYROLYSIS GASOLINE/CRACKING ETHANE,PROPANE,BUTANE,LPG
3135-03	H	1	.	.	PYROLYSIS GASOLINE/CRACKING ETHANE/PROPANE/BUTANE AND NA
3145-01	E	5	.	.	RAYON/VISCOSE PROCESS
3170-01	A	.	.	.	SALICYLIC ACID/CARBOXYLATION OF DRY SODIUM PHENATE
3170-99	C	1	.	.	SALICYLIC ACID/CARBONOXYLATION OF PHENOLATE
3172-01	D1	4	.	.	SAN RESIN/SUSPENSION POLYMERIZATION
3172-02	D1	1	1	.	SAN RESIN/MASS POLYMERIZATION
3175-01	B	3	.	.	SILICONES/SILICONE MONOMERS(CHLOROSILANES) CHLORINATION OF SILICON DIOXIDE
3175-02	E	4	.	.	SILICONES/SILICONE FLUIDS (HYDROLYSIS AND CYCLIZATION)
3175-03	E	1	1	.	SILICONES/SILICONE RESINS
3175-04	E	4	.	.	SILICONES/ SILICONE RUBBERS
3175-05	E	.	.	.	SILICONES/ELASTOMER PRODUCTION
3175-06	E	2	.	.	SILICONES/ SILICONE SPECIALTIES (GREASE,DISPERSION AGENT
3181-01	Z	1	.	.	SODIUM BENZOATE/NEUTRALIZATION OF BENZOIC ACID
3200-99	O	3	.	.	SODIUM FORMATE/ FORMIC ACID + CAUSTIC
3230-01	J2	7	2	.	STYRENE/DEHYDROGENATION OF ETHYLBENZENE
3230-02	2	1	.	.	STYRENE/SEPARATION FROM PYROLSIS GASOLINE
3235-01	D2	5	1	.	STYRENE-BUTADIENE RESIN/ EMULSION PROCESS
3236-01	D1	1	.	.	STYRENE MALEIC ANHYDRIDE RESINS/COPOLYMERIZATION OF STYREN&MAL.ANH.
3237-01	D2	1	.	.	STYRENE-METHYL METHACRYLATE COPOLYMERS/SUSPENSION PROCES

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                       FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR    ZERO    UNK    PP_TEXT

3251-01      M          .       .      .     SULFANILIC ACID/SULFONATION OF ANILINE
3260-99      16         1       .      .     SULFOLANE/ BUTANE + SULFUR
3280-01      C          6       .      .     TEREPHTHALIC ACID/CATALYTIC OXIDATION OF P-XYLENE
3280-03      E          1       .      .     TEREPHTHALIC ACID/HYDROLYSIS OF DIMETHYL TEREPHTHALATE
3286-01      B          1       .      .     1234-TETRACHLOROBENZENE/BY-PRODUCT BENZENE CHLORINATION
3287-01      B          1       .      .     1245-TETRACHLOROBENZENE/BY-PRODUCT BENZENE CHLORINATION
3288-01      B          1       .      .     1235-TETRACHLOROBENZENE/BY-PRODUCT BENZENE CHLORINATION
3291-01      B          1       .      .     1,1,2,2-TETRACHLOROETHANE/CHLORINATION OF ETHYLENE
3295-01      S          .       .      .     TETRACHLOROETHYLENE/ OXYCHLORINATION OF HYDROCARBONS
3295-02      B          5       .      .     TETRACHLOROETHYLENE/CHLORINATION OF EDC & OTHER CHLOR HC
3295-04      B          2       1      .     TETRACHLOROETHYLENE/CHLORINATION OF HYDROCARBONS
3300-01      B          1       .      .     TETRACHLOROPHTHALIC ANHYDRIDE/CHLORINATN OF PHTHALIC ANHYDRIDE
3307-01      6          .       1      .     TETRAETHYLENE PENTAMINE/ETHYLENE DIAMINE + EDC + NH3
3310-01      I2         4       .      .     TETRAETHYL LEAD/ALKYL HALIDE + SODIUM-LEAD ALLOY
3312-01      P          1       .      .     TETRAFLUORODICHLOROETHANE/HYDROFLUORIN OF TETRACHLOROETHYLENE
3315-99      F1         1       .      .     TETRAHYDROFURAN/ HYDROGENATION OF MALEIC ANHYDRIDE
3325-01      5          1       .      .     TETRAETHYLENE GLYCOL/COPDCT OF ETHY GLYCOL FROM ETHYLENE
3325-02      5          .       1      .     TETRAETHYLENE GLYCOL/FROM ETHYLENE GLYCOL STILL BOTTOMS
3338-01      I2         3       .      .     TETRAMETHYL LEAD/ALKYL HALIDE + SODIUM-LEAD ALLOY
3349-00      H          1       1      .     TOLUENE/ STEAM PYROLYSIS OF LPG
3349-01      Z          3       .      .     TOLUENE/DIST OF BTX EXTRACT-CAT REFORMATE
3349-02      Z          .       .      .     TOLUENE/DIST, OF BTX EXTRACT-COAL TAR LIGHT OIL
3349-04      J2         4       1      .     TOLUENE/BY-PRODUCTOF STYRENE MFG
3349-07      2          6       1      .     TOLUENE/DIST OF BTX EXT-PYROLYSIS GASOLINE
3350-01      F2         4       .      .     2,4-TOLUENE DIAMINE/CATALYTIC HYDROGENATION OF DINITROTOLUENE
3351-01      F2         1       .      .     TOLUENE DIAMINE (MIXTURE)/CATALYTIC HYDROGENATION OF DINITROTOLUENE
3354-01      V          3       .      .     2,4-TOLUENE DIISOCYANATE/PHOSGENATN OF 2,4-TOLUENE DIAMI
3355-01      V          4       .      .     TOLUENE DIISOCYANATES(MIXTURE)/PHOSGENATION OF TOLUDIAMS
3360-99      6          .       .      .     TOLUENESULFONAMIDE/ TOLUENE SULFONYLCHLORIDE +NH3
3380-99      M          .       .      .     TOLUENESULFONYL CHLORIDE/ TOLUENE SULFONIC ACID + CHLOROSULFONIC ACID
3381-01      F2         1       .      .     TOLUIDINES/CATALYTIC REDUCTION OF O-NITROTOLUENE
3390-01      B          1       .      .     TRICHLOROBENZENE/BY-PRODUCT OF BENZENE CHLORINATION
3392-01      B          1       .      .     1,2,3-TRICHLOROBENZENE/BY-PRODUCT OF BENZENE CHLORINATION
3393-00      4          .       1      .     1,2,4-TRICHLOROBENZENE/
3393-01      B          1       .      .     1,2,4-TRICHLOROBENZENE/CHLORINATION OF 1,4-DICHLOROBENZ.
3393-02      B          .       .      .     124-TRICHLOROBENZENE/BYPRODUCT OF BENZENE CHLORINATION
3394-01      B          1       .      .     135-TRICHLOROBENZENE/BY-PRODUCT OF BENZENE CHLORINATION
3395-01      B          1       .      .     1,1,1 TRICHLOROETHANE/ CHLORINATION OF ETHYLENE DICHLORD
3395-03      B          1       .      .     1,1,1-TRICHLOETHANE/CHLORINATION OF ETHANE
3395-04      P          1       .      .     1,1,1-TRICHLOROETHANE/HYDROCHLORINATION OF VINYL CHLORIDE
3400-01      B          2       .      .     1,1,2-TRICHLOROETHANE/CHLORINATION OF VINYL CHLORIDE
3400-02      B          .       .      .     1,1,2-TRICHLOROETHANE/CHLORINATION OF ETHYLENE DICHLORID
3400-03      B          .       .      .     1,1,2-TRICHLOROETHANE/BYPDCT, OF VINYL CHLORIDE MANUFACT
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FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
3410-02	S	.	.	.	TRICHLOROETHYLENE/OXYCHLORINATION OF HYDROCARRONS
3410-03	R	2	.	.	TRICHLOROETHYLENE/CHLOR,OF EDC AND OTHER CHLORINATED HC
3411-01	P	4	1	.	TRICHLOROFLUOROMETHANE/FLUORINATION OF CARBON TETRACHLOR
3415-01	R	1	.	.	2,4,6-TRICHLOROPHENOL/CHLORINATION OF PHENOL
3430-01	P	1	.	.	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE/COPROD OF 3312-01
3460-00	5	1	.	.	TRIETHYLENE GLYCOL/ETHYLENE GLYCOL + E.O.
3460-01	5	8	1	.	TRIETHYLENE GLYCOL/COPR,OF ETHYLENE GLYCOL FROM ETH OXD.
3460-02	E	.	.	.	TRIETHYLENE GLYCOL/COFROD OF HYDROLYSIS-ETHYLENE OXIDE
3460-03	5	.	1	.	TRIETHYLENE GLYCOL/FROM ETHYLENE GLYCOL STILL BOTTOMS
3475-01	K	.	1	.	TRIETHYLENETETRAMINE/AMINATION OF ETHYLENE DICHLORIDE
3477-01	P	1	.	.	TRIFLUORODICHLOROETHANE/HYDROFLUORINAT OF TETRACHLOROETHYLENE
3487-01	5	1	.	.	TRIPROPYLENE GLYCOL/RXN OF PROPY GLYCOL + PROPY OXIDE
3488-00	A	1	.	.	2,2,4-TRIMETHYL-1,3-PENTANEDIOL/ ALDOL CONDENSATION ISOBUTYRALDEHYDE
3500-99	3	.	2	.	UREA/ NH3 + CO2
3501-00	D	.	.	.	UNSATURATED POLYESTER RESINS/
3501-01	D1	3	12	.	UNSATURATED POLYESTER RESIN/REACT MALEIC/PHTHALIC/GLYCOL
3503-99	D1	.	1	.	URETHANE PREPOLYMERS/PROCESS UNDER REVIEW
3506-00	D2	.	.	.	UREA RESINS/GENERAL
3506-01	D1	13	22	.	UREA RESINS/POLYCONDENSATION OF UREA WITH FORMALDEHYDE
3510-01	G	1	1	.	VINYL ACETATE/LIQUID PHASE ETHYLENE & ACETIC ACID
3510-03	13	.	1	.	VINYL ACETATE/ACETYLENE + ACETIC ACID
3510-05	G	1	2	.	VINYL ACETATE/VAPOR PHASE RX OF ETHYLENE & ACETIC ACID
3520-03	R	6	1	.	VINYL CHLORIDE/THERMAL CRACKING OF ETHYLENE DICHLORIDE
3520-80	R	2	.	.	VINYL CHLORIDE/FROM ETHYLENE VIA EDC BY CHLOR-OXY CHLOR
3530-02	R	2	.	.	VINYLIDENE CHLORIDE/DEHYDROCHLOR, OF TRICHLOROETHANE
3540-01	D2	.	1	.	VINYL TOLUENE/POLYMERIZATION
3541-01	17	2	.	.	XYLENES-MIXED/BOTTOM BTX EXT-PYROLYSIS GASOLINE
3541-03	17	2	.	.	XYLENES,MIXED/BOTTOM BTX EXTRACT-CAT REFORMATE
3541-04	H	.	.	.	XYLENES,MIXED/BOTTOM BTX EXTRACT-COAL TAR LIGHT OIL
3541-08	17	1	.	.	XYLENES,MIXED/M,P,-XYLENES--BOTTOMS XYLENE SEPARATION
3541-09	Z	.	.	.	XYLENES,MIXED/CRUDE P-XYLENE BY ISOMERIZATION OF C8'S
3550-02	2	.	.	.	M-XYLENE (IMPURE)/FRACTIONATION OF MIXED XYLENES
3560-01	2	3	.	.	O-XYLENE/DISTILLATION FROM MIXED XYLENE
3570-01	17	1	.	.	P-XYLENE/CRYSTALIZATION FROM MIXED XYLENE
3570-02	17	2	.	.	P-XYLENE/ISOMERIZAT-CRYSTALLIZAT OF MIXED XYLENES
3570-05	2	2	.	.	MIXED XYLENES/ FROM BTX EXTRACT
3580-01	H	.	.	.	XYLENOL,MIXED/TAR ACID RECOVERY AND REFINING
3587-00	M	1	.	.	XYLENESULFONIC ACID, SODIUM SALT/
3587-99	M	2	.	.	XYLENESULFONIC ACID, SODIUM SALT/ SULFONATION OF XYLENE
3600-99	3	.	.	.	ZINC(TOTAL)/PROCESS UNDER REVIEW
9601-00	3	.	.	.	AMMONIUM CHLORIDE/
9601-01	3	.	.	.	AMMONIUM BICARBONATE/
9603-00	M	1	.	.	CYCLOHEXYL MERCAPTAN/ DODECENCNE + H2S

FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
9604-00	D1	.	.	.	DH - 50% RAYON GRADE/
9604-01	16	.	1	.	2,4-DIMETHYL PHENOL/ EXTRACTION, DISTILLATION OF REFINERY SPENT CRESYLATES
9608-00	H	1	.	.	N-HEXADECYL MERCAPTAN/ OLEFIN +H2S
9608-01	H	1	.	.	N-HEXYL MERCAPTAN/ OLEFIN + H2S
9612-00	H	1	.	.	D-LIMONENE DIMERCAPTAN/ OLEFIN + H2S
9615-00	I	.	1	.	P-TERT-OCTYL PHENOL/
9616-00	D1	1	.	.	POLYAMIDE RESINS/
9616-01	3	.	.	.	PHOSPHORIC ACID/
9619-00	3	.	.	.	SODIUM NITRATE/
9619-01	3	.	.	.	SODIUM BICARBONATE/
9619-02	3	.	1	.	SODIUM HYDROSULFIDE/
9619-03	3	.	.	.	SODIUM SULFIDE/
9619-04	E	2	.	.	SODIUM SULFATE/RECOVERY AS PART OF VISCOSE PROCESS
9619-05	3	.	.	.	SODIUM TETRASULFIDE/
9626-00	4	.	.	.	ZEREMBA/
9801-01	H	2	.	.	ACETYLENICS/ STEAM PYROLYSIS
9801-02	3	1	1	.	AGRICULTURE CHEMICALS/
9801-04	H	1	1	.	AROMATIC CONCENTRATE/ STEAM PYROLYSIS OF CRUDE OIL CUTS, OR LPG
9801-05	D1	2	.	.	ACRYLAMIDE RESINS/
9801-06	O	3	.	.	GLYCOLS, MIXED/ OLEFIN OLIGOMERS + OXO, HYDROGENATION
9801-09	16	.	.	.	AROMATIC SOLVENTS/ BTX EXTRACTION FROM PYROLYSIS GASOLINE
9801-11	6	1	.	.	ANTIOXIDANTS/
9801-12	3	.	.	.	ASPHALT/REFINERY PRODUCT
9801-13	2	.	.	.	ALIPHATIC SOLVENTS/ DISTILLATION FROM PYROLYSIS GASOLINE
9801-14	6	1	.	.	ACCELERATORS(TRADE NAME)/ MERCAPTOBENZOTHIAZOLES
9801-15	6	1	.	.	ANTIOZONANTS/
9801-16	D1	1	.	.	ACETAL RESIN (CELCON)/
9801-18	5	1	.	.	MISCELLANEOUS ALKOXYLATES/
9801-19	6	2	1	.	MISCELLANEOUS AMIDES/ FATTY ACIDS + ALKANOLAMINES
9801-21	I	2	.	.	ANTI KNOCK BLENDS/ LEAD ALKYLS, ETHYLENE DICHLORIDE
9801-23	H	1	.	.	AROMATIC TAR/ STEAM PYROLYSIS RESIDUALS
9801-24	H	1	.	.	AROMATIC DISTILLATES/ BTX
9801-25	6	2	.	.	AMINES /METHANOL + NH3
9801-26	I	1	.	.	ALUMINUM ALKYLS/ OLEFIN + ALUMINUM + HYDROGEN
9801-27	3	1	1	1	ADHESIVES/

FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

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PP_CODE GEN_CODE DIR ZERO UNK PP_TEXT

9801-29    F2      .    1    .   MISC. ALKANES/
9801-30    A       .    1    .   ALKENYL SUCCINIC ANHYDRIDES/
9801-31    5       .    .    .   ALKATERGE(TRADE NAMF)/ ETHOXYLATION OF ALKYL PHENOL
9801-34    A       .    .    .   AMANTADINE HYDROCHLORIDE/
9801-35    D1      .    1    .   ALKYD HOLDING COMPOUND (TRADE NAME)/
9801-36    4       .    .    .   ALPHA 841 PRODUCTS (TRADE NAME)/
9801-40    A       .    1    .   AMINO ALCOHOLS/ ALDOL CONDENSATION OF NITROPARAFFINS WITH FORMALDEHYDE, REDUCTION
9801-42    3       .    1    .   ACRYLONITRILE CATALYST/ BISMUTH PHOSPHOMOLYBDATE, SR-U207-SILICA GEL
9801-43    6       1    .    .   ALKYLOLAMIDES/ FATTY ACIDS + ALKANOLAMINES
9801-47    3       .    .    .   ANTIBIOTICS/
9801-48    D1      .    .    .   ACETONE FORMALDEHYDE RESINS/
9801-49    4       .    .    .   ADDITIVES MISCELLANEOUS/
9801-51    14      1    .    .   ALKYL VINYL ETHERS/ ACETYLENE + ALCOHOL
9801-53    4       .    .    .   AMEX (TRADE NAME)/
9801-58    F2      .    .    .   ACETYL P-AMINOPHENOL (P-HYDROXYACETANILIDE) / NITRATION, HYDROGENATION ACETYLATION OF PHENOL
9802-04    12      1    .    .   N-BUTYL FORMCEL/ SOLUTION OF FORMALDEHYDE IN BUTANOL
9802-05    3       .    .    .   BUNKER C FUEL/
9802-11    3       1    .    .   BROMACIL-DIURON COMPLEX (HERBICIDE)/
9802-12    3       1    .    .   BROMACIL(HERBICIDE)/
9802-13    3       1    .    .   BENOMYL/
9802-14    3       1    .    .   BENLATE/
9802-15    A       1    .    .   BIS-PARA-AMINOCYCLOHEXYL-METHANE/ ANILINE + FORMALDEHYDE, HYDROGENATION
9802-17    3       .    .    .   BACITRACIN PRODUCTS/
9802-18    G       .    .    .   BUTYL LACTATE/ BUTANOL + LACTIC ACID
9802-21    M       1    .    .   N-BUTYL MERCAPTAN/ OLEFIN + H2S
9802-22    M       1    .    .   SEC-BUTYL MERCAPTAN/ OLEFIN + H2S
9802-23    M       1    .    .   T-BUTYL MERCAPTAN/ OLEFIN + H2S
9802-24    D1      .    1    .   BAREX RESIN (POLYACRYLONITRILE BARRIER RESIN)
9802-36    A       1    .    .   BUTYNEDIOL/ ACETIYLENE + FORMALDEHYDE
9802-37    A       2    .    .   1,4 BUTANEDIOL/ CONDENSATION ACETYLENE WITH FORMALDEHYDE, FOLLOWED BY HYDROGENATION
9802-38    J       1    .    .   3-BUTYROLACTONE/ DEHYDROGENATION OF 1,4-BUTANEDIOL (COPPER CAT)
9802-39    F2      1    .    .   2-BUTENE-1,4-DIOL/ HYDROGENATION OF BUTYNEDIOL
9803-02    G       1    .    .   CELLULOSE BASED ORGANIC (CYTREL)/ CELLULOSE + ACETIC ANHYDRIDE
9803-04    2       .    .    .   CARBON BLACK FEEDSTOCK/ DISTILLATION FROM PYROLYSIS GASOLINE
9803-05    B       .    1    .   CHLOROBUTADIENE/ CHLORINATION DEHYDROCHLORINATION OF BUTADIENE
9803-06    A       .    1    .   1-(3-CHLOROALLYL)-3,5,7-TRLAZA-(1-AZONIAADAMANTANE CHLORIDE) 1,3-DICHLOROPROPENE+FORMALDEHYDE+AMMONIA
9803-11    3       1    .    .   CLAY POLYMER/CLAY POLYMER
9803-13    3       1    .    .   COATED FILM/
9803-14    R       1    1    .   CHLOROPRENE/  DEHYDROCHLORINATION OF 3,4-DICHLORO BUTENE-2
9803-15    B       1    .    .   CHLOROBUTADIENE/  CHLORINATION - DEHYDROCHLORINATION OF BUTADIENE
9803-16    O       1    .    .   CALCIUM FORMATE/ CO + LIME
9803-17    6       .    .    .   CHOLINE FEED SUPPLEMENTS/
9803-18    3       .    .    .   CYCLOSERINE (4 - AMIND - 3 - ISOXAZOLIDINONE)
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FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

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PP_CODE    GEN_CODE    DIR    ZERO    UNK    PP_TEXT

9803-19       6         .      .       .     CHOLINE BICARBONATE/ CHOLINE + SODIUM BICARBONATE
9803-22       B         1      .       .     CHLORINATED WAX/
9803-25       3         .      2       .     COATINGS/
9803-26       3         .      .       .     CALCIUM PROPIONATE/
9803-27       A         .      1       .     CHELATING AGENTS/ EDTA = ETHYLENEDIAMINE + FORMALDEHYDE + NACN
9803-28       K         .      1       .     CLEANING COMPOUNDS/ VEGETABLE OIL SULFONATES, ETHOXYLATES, QUATS
9803-39       F1        .      .       .     CROTON OIL ALCOHOL/ HYDROGENATION OF CROTONALDEHYDE
9803-42       15        .      .       .     C-5 UNSATURATES/ FROM PYROLYZATE BY EXTRACTIVE DISTILLATION
9803-45       14        .      .       .     CHEMICAL COTTON/ CELLULOSE + ETHYLENE CHLOROHYDRIN
9803-46       G         1      .       .     CORPENT/ PENTAERYTHRITOL DERIVATIVE
9803-53       3         .      .       .     COAL ASH/
9804-02       6         1      .       .     DIAMINO DIPHENYL METHANE/  ANILINE + FORMALDEHYDE
9804-04       6         .      .       .     N,N,DIISOPROPYL-2 BENZOTHIAZOLE/DIISOPROPYL AMINE + 2-MERCAPTOBENZOTHIAZOLE
9804-06       4         .      .       .     DISTILLATE, LIGHT,N-BUTANE DEHYDRO./RECOV.
9804-08       3         .      .       .     DIESEL FUEL/
9804-10       3         1      .       .     DIURON(TRADE NAME)/
9804-12       K         1      .       .     DIMETHYLACETAMIDE/ DIMETHYLAMINE + ACETIC ACID
9804-13       A         .      .       .     DIMER ACIDS/ FROM PINE ROSIN
9804-14       6         .      .       .     DIAMINES/
9804-15       Q         1      .       .     DIETHYL ANILINE/ ANILINE + ETHANOL + H2SO4
9804-17       4         1      .       .     DACA/
9804-19       13        .      .       .     DIATRIZOIC ACID/
9804-20       G         1      .       .     DIETHYL MALONATE/ ETHANDL ESTER OF MALONIC ACID
9804-21       G         1      .       .     DIMETHYL MALONATE/ METHANOL ESTER OF MALONIC ACID
9804-22       12        .      .       .     DENATURED ALCOHOL/
9804-24       G         .      1       .     DYEING ASSISTANTS/ POLYESTERS
9804-25       K         .      1       .     DETERGENTS AND SCOURS/ VEGETABLE OIL SULFONATES, ETHOXYLATES, QUATS
9804-27       D1        .      1       .     DIALLYLPHTHALATE MOLDING COMPOUND/
9804-29       M         1      .       .     N-DECYL MERCAPTAN/ OLEFIN + H2S
9804-30       M         1      .       .     N-TRI-DECYL MERCAPTAN/ OLEFIN + H2S
9804-31       24        .      1       .     DISODIUMETHYLENEDIAMINETETRAACETATE/ NEUTRALIZATION OF EDTA
9804-36       M         1      .       .     DICHLORODIPHENYL SULFONE/SO3 +THIONYL CL + CHLOROBENZENE
9804-47       9         1      .       .     DIMETHYLBENZYL ALCOHOL/ ACID CLEAVAGE OF CUMENE HYDROPEROXIDE
9804-48       D1        1      .       .     DICYANODIAMINE RESIN/
9804-49       M         2      .       .     DODECYLBENZENE SULFONIC ACID SALTS/ SULFONATION OF DODECYLBENZENE
9804-52       G         .      .       .     DIBUTYLPHENYL PHOSPHATE/ BUTANOL + PHENOL + POCL3
9804-53       6         .      .       .     2,6-DIETHYL-N-(METHOXYMETHYL)-2-CHLOROACETANILIDE/
9804-54       6         .      .       .     2,6-DIETHYLPHENYL AZOMETHANE/
9804-57       U         1      .       .     DINONENE/ FROM TERPINENE SY DEALKYLATION
9804-58       5         1      .       .     DIETHANOL AMMONIUM LAURYL SULFATE/ LAURYLAMINE + ETHYLENE OXIDE
9805-03       6         .      .       .     N-ETHYL ANILINE/ ETHANOL + ANILINE
9805-04       4         .      .       .     2-ETHYL HEXYL CHLORIDE/
9805-05       G         2      .       .     MISCELLANEOUS  ESTERS (POSSIBLY ADIPATES) / ADIPIC ACID + 2-ETHYLHEXANOL
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FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
9805-08	D1	1	.	.	EASTOBONDS (TRADE NAME)/ POYSTYRENES AND CELLULOSICS (ADHESIVES FOR POLYOLEFINS)
9805-09	24	.	.	.	ETHYLENEDIAMINE - DIHYDROIODIDE/ HI + ETHYLENEDIAMINE
9805-12	D1	1	.	.	ELASTOMER LATEX/
9805-14	D1	.	1	.	EMULSION POLYMERS/
9805-17	M	1	.	.	ETHYL MERCAPTAN/ OLEFIN + H2S
9805-18	14	1	.	.	DI-ETHYL SULFIDE/ K ETHYLSULFATE + K2S (AQ)
9805-19	A	.	1	.	ETHYLENEDIAMINETETRAACETIC ACID/ ETHYLENEDIAMINE + FORMALDEHYDE + NACN
9805-22	5	1	.	.	MONOETHYL GLYCOL ETHER/
9805-29	18	.	1	.	ETHYLENE CYANOHYDRIN/ ACETALDEHYDE + HCN
9805-31	A	1	.	.	ETHYLENE UREA/ ETHYLENE DIAMINE + CO2
9805-36	D1	.	2	.	ALKYD,PHENOLIC, POLYESTER, POLYURETHANE RESINS
9806-01	3	2	.	.	FUEL GAS H2 AND CH4 (MFG)/
9806-02	4	.	.	.	FUEL ADDITIVES/
9806-03	3	.	.	.	FLOUR ADDITIVES/
9806-04	E	1	1	.	FATTY ACIDS & DERIVATIVES/ HYDROLYSIS OF GLYCERIDES
9806-05	G	.	1	.	FATTY NITRILES/ DEHYDRATION OF FATTY AMIDES
9806-06	3	.	.	.	NUMBER 2 FUEL OIL/
9806-08	P	1	.	.	FREON (GENERAL)/HYDROFLUORINATION
9806-09	D1	.	1	.	FLEXTAL/ ALKYD RESINS
9806-11	P	1	.	.	FLUOROCARBON BLENDS/ HF + CHLORINATED METHANE
9806-12	3	.	.	.	FURAZOLIDONE/ REDUCTION OF NITROFURANTOIN
9806-13	4	.	.	.	FLOWCO FAMILY/
9806-14	D1	.	1	.	FURFURAL RESIN (INC. FURAN)/
9806-15	D1	.	.	.	FOAM RESINS (POLYURETHANES)
9806-17	D1	1	.	.	FOME-COR/
9806-19	3	1	.	.	FUNGICIDE AND INSECTICIDE/
9807-01	4	.	.	.	GENEROL 100 EXTRACTION/
9807-02	3	.	.	.	GENEROL 105 FLAKING/
9807-04	7	1	.	.	GLYCOLONITRILE/ ETHYLENE CHLOROHYDRIN + NACN
9807-06	3	3	.	.	GASOLINE/
9807-07	16	1	.	.	GASOLINE BLEND STOCK/ FROM PYROLYZATE BY EXTRACTIVE DISTILLATION
9807-08	D1	1	.	.	GANTREZ AN/ POLYMERIZATION OF VINYL ETHER AND ACRYLONITRILE
9807-09	G	1	.	.	GANTREZ ES/ESTERIFICATION PROPAGYL ALCOHOL + ACID
9807-12	D2	1	.	.	POLYMER GASOLINE/BY-PRODUCT ISOBUTYLENE
9807-13	5	1	.	.	GYCOLS(MISC.)/ ALCHOHOL, GLYCOL + ETHYLENE OXIDE
9808-02	6	.	1	.	HEXAMETHYLENEDIAMINE / 1,6 - HEXANEDIOL + AMMONIA (NICKLE CAT.)
9808-05	3	1	.	.	HYDROGEN SULFIDE/
9808-08	12	1	.	.	HYDROXYACETIC ACID/ CHLOROACETIC ACID + CAUSTIC
9808-09	D2	1	.	.	HYPOLON(TRADE NAME)/ CHLOROSULFONATED POLYETHYLENE RUBBER
9808-10	D2	1	.	.	HYDAN (TRADE NAME)/
9808-11	E	.	.	.	HYDROLYZED VEGETABLE PROTEIN/
9808-12	3	.	.	.	HLR/
9808-16	G	.	.	.	HYDROXY STEARIC ACID AND DERIVATIVES/

FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
9808-17	3	.	1	.	HYDROXYLAMMONIUM ACID SULFATE/
9808-18	3	.	1	.	HYDROXYLAMMONIUM SULFATE/
9808-28	H	2	.	.	LIGHT HYDROCARBONS/
9808-31	M	1	.	.	HYDROTROPE/ SULFONATION OF ALKYL BENZENES (ALKY=METHY, ETHYL,ISOPROPYL)
9809-01	A	.	1	.	ISOPROPYL ETHYTHIONO CARBAMATE/ ALPHA-METHYL PROPIONAMIDE + SODIUM ETHYLMERCATIDE
9809-03	D1	1	.	.	ION EXCHANGE RESINS (PROBABLY ACRYLIC RESINS)
9809-04	3	.	.	.	ISOMERASE/
9809-07	G	.	1	.	ISOPHTHALATE ESTER/ESTERIFICATION
9809-11	V	2	.	.	MISCELLANEOUS ISOCYANATES/ PHOSGENTATION OF ANILINE-FORMALDEHYDE DERIV.
9809-19	F1	1	1	.	ISOBUTYRONITRILE/ FROM ALPHA-METHACRYLONIYRILE BY HYDROGENATION
9810-01	3	.	.	.	JET FUEL JP-4/
9811-01	8	.	.	.	KETONE PEROXIDE (DIACETONE ALCOHOL PEROXIDE) / PEROXIDATION OF DIACETONE ALCOHOL
9811-02	3	.	.	.	KEROSENE/
9811-03	D1	.	.	.	KETONE RESINS/
9811-04	D1	1	.	.	KEVLAR (ARAMID RESIN AND FIBER)/ISOPHTHALOYL CHLORIDE + 1,3-DIANILINE (TYPICAL) AN AROMATIC NYLON
9812-04	D1	.	.	.	LAMINATING RESINS/ CRESYLIC ACID-PHENOL + FORMALDEHYDE
9812-05	3	1	.	.	LINURON(HERBICIDE)/
9812-07	3	.	.	.	LOROX/
9812-08	3	.	1	.	LACQUER(GENERAL)/
9812-09	A	.	1	.	LAUROYL SARCOSINATE (30 PERCENT SODIUM SALT)/ SARCOSINE + LAURALDEHYDE
9812-10	3	.	.	.	LUBRICANTS / ORGANIC PERIOXIDES, PEROXYCARBONATES, ETC
9812-12	8	1	.	.	LUPERSOL (TRADE NAME) / ORGANIC PERIOXIDES, PEROXYCARBONATES, ETC
9812-13	8	1	.	.	LUPERCO (TRADE NAME) / ORGANIC PERIOXIDES, PEROXYCARBONATES, ETC
9812-14	8	1	.	.	LUPEROX (TRADE NAME)/
9812-15	3	1	.	.	LIGHT OILS/
9812-16	D1	.	1	.	LATEX(UNKNOWN TYPE)/ POLYVINYLACETATE
9813-01	10	.	.	.	METHYLETHYL KETOXIME/METHYLETHYL KETONE + HYDROXYLAMINE _(NH2OH)2-H2SO4,
9813-02	G	.	1	.	MALEIC ACID ESTERS/ESTERIFICATION
9813-04	24	.	.	.	2-MERCAPTOBENZOTHIAZOLE, ZINC SALT/ ZINC OXIDE + 2-MERCAPTBENZOTHIAZOLE
9813-05	24	.	.	.	2 MERCAPTOBENZOTHIAZOLE, SODIUM SALT/ CAUSTIC + 2-MERCAPTBENZOTHIAZOLE
9813-06	A	.	.	.	2,2' METHYLENEBIS(6-T-BUTYL-4-EHTYLPHENOL)/ 4-ETHYL-6-T-BUTYYLPHENOL + FORMALDEHYDE
9813-07	12	1	.	.	METHYL FORMCEL/ SOLUTION OF FORMALDEHYDE IN METHANOL
9813-08	3	.	.	.	MOTOR GASOLINE/
9813-09	2	1	.	.	MIXED C4 COMPOUNDS/ DISTILLATION FROM BTX RAFFINATE
9813-10	3	1	.	.	MOTOR MIX I/
9813-11	3	1	.	.	MOTOR MIX/
9813-12	A	1	1	.	METHYL MERCAPTAN/ METHYL CHLORIDE + SODIOM HYDROSULFIDE
9813-13	3	1	.	.	METHOMYL/
9813-14	3	1	.	.	MANEB (FUNGICIDE)/
9813-16	D1	.	2	.	MOLDING COMPOUNDS/ (POLYACRYLIC RESINS)
9813-20	D1	1	.	.	MISC.PLASTIC RESINS,SHAPES,CHEMICAL/
9813-22	G	1	.	.	METHYL CYANOACETATE/ METHANOL ESTER OF CYANOACETIC ACID
9813-23	14	1	.	.	METHYL ORTHOFORMATE/ CHLOROFORM + NAMETHANOLATE

FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

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         G
P        E                    P
P        N                    P
_        _            Z       _
C        C            E       T
O        O      D     E   U   E
D        D      I     R   N   X
E        E      R     O   K   T

9813-24  6      .     .   .   MORPHOLINE DERIVATIVES OF NITRO ALCOHOLS/
9813-25  D2     1     .   .   MICROTHENE (POWDERED PLOYETHYLENE RESIN)
9813-26  2      1     .   .   METHANE/
9813-28  G      .     1   .   CASTOR OIL DERIVATIVES/ (ESTERS)
9813-29  G      .     1   .   TRIMELLITATE ESTER/ESTERIFICATION
9813-30  A      .     1   .   N-METHYL GLYCINE (SARCOSINE) / METHYLAMINE + FORMALDEHYDE + NACN
9813-31  G      .     1   .   MALEANIZED OIL/ OIL + MALEIC ANHYDRIDE
9813-39  G      1     .   .   TEXANOL BENZOATE/ ESTERIFICATION OF BENZOIC ACID
9813-41  G      1     .   .   METHOXYETHYL CARBAMATE/ 2-METHOXYETHANOL + CARBAMOYL CHLORIDE (HCL+UREA)
9813-43  G      .     1   .   MALEATED OILS/ MALEIC ANHDRIDRIDE + OILS WITH HYDROXYL GROUPS
9813-45  6      1     .   .   N-METHYL-2-PYRROLIDONE/ 3-BUTYROLACTONE + METHYLAMINE
9813-46  A      .     .   .   METHYL AMYL ALCOHOL/ ALDOL CONDENSATION OF ACETONE
9813-48  3      1     .   .   METALLIC CARBONYLS (MISC.)/
9813-49  A      .     .   .   2,2' METHYLENEBIS(6-T-RUTYL-P-CRESOL)/
9813-50  A      1     .   .   METHOXY DIHYDROPYRAN/
9814-01  A      1     .   .   NITRILOTRIACETATE/ NH3 + FORMALDEHYDE + NACN
9814-02  14     1     .   .   NAPHTHA OXIDE OILS/ SODIUM PHENOLATE + CHLOROBENZENE
9814-03  A      .     .   .   4,NITRO-ORTHO-XYLENE DIETHYL KETONE BLEND/ MIX OF 2 PRODUCTS
9814-06  D1     1     .   .   PARAFORMALDEHYDE/ POLYMERIZATION OF FORMALDEHYDE (ALDOL, CANNIZARO)
9814-07  D2     1     .   .   NORDEL (TRADE NAME)/ETHYLENE - PROPYLENE COPOLYMERS
9814-08  3      1     .   .   NYLON YARN/FROM PURCHASED RESIN
9814-11  L      1     .   .   5-NITRO-O-TOLUENE SULFONIC ACID/ SULFONATION OF TOLUENE, NITRATION
9814-13  L      1     .   .   1-NITRO-3,4-DICHLOROBENZENE/ NITRATION OF O-DICHLOROBENZENE
9814-15  D1     1     .   .   NAMEX (ARAMID RESIN,FIBER AND SHEET)/ ISOPHTHALOYL CHORIDE + 1,3-DIANILINE (TYPICAL) AN AROMATIC NYLON
9814-16  3      .     1   .   NRD-47/
9814-17  D1     1     .   .   NYLON/DACRON COSPUN FIBER/(DACRON POLYESTER)
9814-18  D2     2     .   .   NEOPRENE/ (3-CHLORD-1,3-BUTADIENE)
9814-19  A      .     .   .   NITRO AND AMINO ALCOHOL/ ALDO CONDENSATION OF NITROPARAFFINS WITH FORMALDEHYDE
9814-21  3      .     .   .   NITROFURANTOIN/ 1-AMINOHYDANTOINSULFATE + 20-NITROFURALDEHYDE DIACET TE
9814-22  V      1     .   .   1-NAPHTHYLN-METHYLCARBAMATESEVIN / METHYL AMINE + PHOSGENE + 1-NAPHTHOL
9814-24  M      1     .   .   NONYL MERCAPTAN/ ALPHA-OLEFINS + H2S
9814-25  L      .     1   .   NITROPARAFFINS/ NITRATION OF METHANE, ETHANE, PROPANE (HIGH TEMP, VAP PHASE)
9814-26  A      .     1   .   NITROALCOHOLS/ ALDOL CONDENSATION OF NITROPARAFFINS WITH FORMALDEHYDE
9814-27  3      .     .   .   NUSOL/EXTRACTION FROM SULFITE PULP MILL WASTEWATER
9814-28  3      1     1   .   NITROGEN FERTILIZER SOLUTIONS/
9814-31  14     .     .   .   P-NITROPHENETOLE/ P-NITROPHENOLATE + ETHYL CHLORIDE
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                         FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR    ZERO    UNK    PP_TEXT

9814-32       0         .       .      .     NONYL&CUMYL PHENYL DIPHENYL PHOSPHATE/ ALKYL PHENOLS, PHENOL + POCL3
9814-38       2         .       .      .     SOLVENT NAPHTHA/ DISTILLATION FROM COALTAR CONDENSATE
9814-39       L         1       .      .     NITROCHLOROBENZENE/ NITRATION OF CHLOROBENZENE
9815-01       3         .       3      .     MISC. REFINERY OILS/
9815-02       11        .       .      .     OCTYLATED DIPHENYLAMINE/ALKYLATION
9815-03       8         .       .      .     ORGANIC PEROXIDE/
9815-08       02        4       .      .     OLEFINS MIXED/ ETHYLENE OLIGOMERS E
9815-09       01        .       1      .     OXAWAXES/ RESIDUES FROM OXAZOLIDINES PRODUCTION
9815-10       3         .       .      .     OXAZOLIDINES/
9815-12       E         .       .      .     OCTADECADIENOIC ACID MIX/
9815-14       M         1       .      .     T-OCTYL MERCAPTAN/ ALPHA-OLEFINS + H2S
9815-15       M         1       .      .     N-OCTYL MERCAPTAN/ ALPHA-OLEFINS + H2S
9815-16       4         2       .      .     MISC. ORGANICS/
9815-19       C         .       .      .     ORGANIC ACIDS (MIXED)/ OXIDATION OF PROPIONALDEHYDE CONDENSATES
9815-22       10        .       .      .     OXIMES,MISC./ CARBONYL CMPD + HYDRXYL AMINE
9816-01       01        1       .      .     POLY METHYLENE DIPHENYL DIISOCYANATE/(POLYMERIC MDI)
9816-03       02        2       .      .     ATACTIC POLYPROPYLENE/BYPRODUCT OF 3020-03
9816-05       0         .       .      .     PEROXY ESTERS (T-BUTYL ESTERS OF PERBENZOIC, PEROCTANOIC, PERACETIC ACIDS
9816-07       6         .       .      .     POLYAMINES/
9816-08       02        2       .      .     POLYBUTADIENE RESINS/
9816-09       01        2       .      .     POLYBUTYLENE TEREPHTHALATE (PBT)/
9816-11       23        1       .      .     POLYESTER YARN/
9816-13       3         .       1      .     PIGMENTED FINISHES/
9816-14       3         1       .      .     PARAFFINS/
9816-15       D         .       .      .     POLYETHYLENE FOAM/
9816-16       01        .       2      .     POLYESTER IMIDE (TML)/
9816-21       3         2       .      .     POLYPROPYLENE FILM/
9816-22       02        .       .      .     POLYELECTROLYTE/ POLYACRYLAMIDE
9816-23       6         1       .      .     PHENYL GLYCINE/ANILINE + CHLOROACETIC ACID
9816-25       3         .       .      .     PROTEIN GLUE/
9816-27       3         .       2      .     PAINT-GENERAL/
9816-29       5         1       .      .     POLYETHYLENE OXIDE/
9816-31       02        .       .      .     PICCOVAR RESIN/
9816-36       02        .       .      .     PICCO 6100 RESIN/
9816-37       02        .       .      .     PICCOMER/
9816-38       01        1       1      .     PHENOLIC MOLDING COMPOUND/
9816-42       02        .       .      .     POLYETHYLENE XYLENE MIXTURE/
9816-43       02        .       .      .     POLYETHYLENE TOLUENE MIXTURE/
9816-44       12        1       .      .     POLYOLS/ ALKOXYLATION OF FATTY ALCOHOLS, PROPYLENE GLYCOL AND GLYCEROL
9816-45       4         1       .      .     PHENYLETHYLPHENYL METHANE/
9816-46       M         1       .      .     N-PROPYL MERCAPTAN/ ALPHA-OLEFINS + H2S
9816-47       M         1       .      .     I-PROPYL MERCAPTAN/ ALPHA-OLEFINS + H2S
9816-48       F1        1       .      .     O-PHENYL PHENOL/ FROM DIBENZOFURAN
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FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
9816-49	24	.	1	.	PENTASODIUM DIETHYLENEDIAMINE PENTAACETATE / EDPA + CAUSTIC
9816-50	3	.	.	.	PHENOLIC COATED PAPERS/
9816-51	3	.	.	.	POLYESTER COATED PAPERS/
9816-54	3	.	1	.	PLYWOOD OVERLAYS/
9816-56	3	.	.	.	PAPER GENERAL/
9816-58	5	2	.	.	POLYETHER/ PROPOXYLATION OF PROPYLENE GLYCOL
9816-69	D1	1	.	.	POLY DIETHYLENE GLYCOL ADIPATE (POLYESTER)
9816-71	5	.	1	.	ETHOXYLATED PHENOLS/PHENOLS + ETHYLENE OXIDE
9816-72	3	.	.	.	PENICILLIN/
9816-75	G	.	1	.	PLASTICIZERS (PATHALATES, ADIPATES, SEBACATES) / PHTHALIC ANHYD. + ALCOHOL
9816-77	D1	.	2	.	POLYVINYL FORMAL/
9816-80	3	.	.	.	PARATHIONS/
9816-83	D1	1	.	.	POLYETHER POLYOL RESINS/
9816-87	K	1	.	.	2-PYRROLIDONE/3-BUTYROLACTONE + NH3
9816-93	6	.	.	.	POLY-N (TRADE NAME)/ ORGANO-UREA POLYMER
9816-97	3	.	.	.	POLYETHYLENE COMPOUNDS/COMPOUNDING
9816-98	3	.	.	.	PLASTIC COMPONENT/
9816-99	3	1	.	.	PLASTIC BATTERY SEPARATORS/
9817-01	6	.	1	.	QUATERNARY AMINES/ ALKYL CHLORIDE + FATTY AMINE
9818-01	D2	1	.	.	RESIN PR/STILL BOTTOMS FROM STEAM PYROLYSIS OF NAPTHA/ GAS OIL
9818-02	H	1	.	.	RESIN OIL (AROMATIC)/STEAM PYROLYSIS OF GAS OIL
9818-05	H	1	.	.	REACTIVE DISTILLATES FROM STREAM CRACKING/
9818-06	6	.	.	.	RESINS SOLUTIONS/
9818-07	3	.	.	.	ROSINS AND DERIVATIVES/
9818-08	D1	.	1	.	ROSIN DERIVATIVE RESINS/
9818-09	3	.	1	.	READSORBER OFF-GASES/
9818-10	E	.	.	.	RICINOLEIC ACID/FROM CASTOR OIL BY HYDROLYSIS
9818-11	G	.	.	.	RICINOLEATES AND DERIVATIVES/ RICINOLEIC ACID + ALCOHOL
9818-14	16	.	.	.	RAFFINATE/ BTX EXTRACT OF COAL TAR CONDENSATE
9818-15	D1	.	1	.	RUBBER RESINS(POLYURETHANE ELASTOMERS)
9818-16		1	.	.	
9818-17	D1	1	.	.	RUBBER-CYCLIZED/
9818-19	D1	1	.	.	RESINS (GENERAL)/
9819-01	G	3	1	.	SURFACTANTS/ SULFOSUCCINIC ACID ESTERS = SUCCINIC ACID + ALCOHOL + SODIUM BISULFITE
9819-02	3	.	.	.	SULFAMETHAZINE/ CONDENSATION OF SULFAGUANIDINE AND ACETYLACETONE + SODIUM BISULFITE
9819-04	3	1	.	.	SOLVENT BLENDS, MISCELLANEOUS/
9819-09	5	1	.	.	SODIUM METHYLATE/METHANOL + SODIUM
9819-10	D1	1	1	.	SPANDEX FIBERS (85% SEGMENTED POLYURETHANE) / POLYOL + DIISOCYANATES
9819-11	M	1	.	.	SODIUM LAURYL SULFATE/ SULFONATION OF LAURYL ALCOHOL
9819-14	M	1	.	.	SODIUM STYRENE SULFONATE/ SULFONATION OF STYRENE
9819-15	4	1	.	.	SPECIALTY LUBRICANTS/
9819-17	24	.	.	.	SODIUM PROPIONATE/ PROPIONIC ACID + CAUSTIC
9819-18	A	1	2	.	TEXTILE SOFTENERS/ UREA + FORMALDEHYDE + GLYOXAL

FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
9819-19	G	.	.	.	MISCELLANEOUS STEARATES/ STEARIC ACID + ALCOHOL
9819-22	G	.	.	.	SYNTHETIC LUBRICANTS/
9819-26	M	1	.	.	FATTY ESTER SULFONATES/ SULFONATION OF FATTY ACIDS
9819-27	M	1	.	.	LAURYL SULFONATES/ SULFONATION OF DODECENE
9819-28	M	1	.	.	LINEAR ALKYLATE SULFONATE/ SULFONATION OF ALKYLBENZENES
9819-35	3	.	1	.	SOLVENT BASE COATING/
9819-36	D2	1	.	.	SYNTHETIC SPECIALTY POLYMERS (POLYSTYRENE)
9819-38	4	.	1	.	SOLUTIONS (MISCELLANEOUS)/
9819-39	M	1	.	.	SODIUM LINEAR ALKYL BENZENE SULFONATE/ SULFONATION OF ALKYLBENZENE
9819-40	24	.	.	.	SODIUM NITROBENZENESULFONIC ACID/
9819-42	D2	1	1	.	STYROFOAM/ EXTRUDED EXPANDED POLYSTYRENE
9819-43	3	1	1	.	SPECIALITY PAPERS/
9819-45	L	1	.	.	SUBSTITUTED PHENOLS(MISC.)/NITRATION
9820-03	C	1	.	.	TRIMELLITIC ANHYDRIDE/ OXIDATION OF PSEUDOCUMENE (1,2,4-TRIMETHYL BENZENE)
9820-04	A	1	.	.	TRIMETHYLOLPROPANE/ N - BUTYRALDEHYDE + FORMALDEHYDE (ALDOL, CANNIZARO)
9820-05	A	1	.	.	TRIOXANE/ FORMALDEHYDE TRIMER
9820-06	3	2	.	.	TETRAMIX (TRADE NAME)/
9820-07	M	.	1	.	2,3,5,6-TETRACHLORO-4-(METHYL SULFONYL) PYRIDINE/
9820-08	M	.	1	.	2,3,5-TRICHLORO-4-(N-PROPYL SULFONYL) PYRIDINE/
9820-10	3	1	.	.	TETRAMETHYL THIURAM MONOSULFIDE/
9820-11	3	1	.	.	THIRAM(INSECTICIDE,VULCANIZER)/
9820-12	3	1	.	.	TERBACIL/
9820-13	3	1	.	.	TRIAZINE DIONE/CONDESATION OF UREA, DEHYDROGENATION
9820-14	3	1	.	.	TETRAETHYL THIURAM DISULFIDE/
9820-16	4	.	1	.	THINNER/
9820-17	D2	1	.	.	TYVEK (SPUNBONDED POLYOLEFIN)/ HD POLYETHYLENE SHEET
9820-18	2	.	.	.	TERPENE/
9820-19	3	.	1	.	TOTAL OILS/
9820-20	A	1	.	.	TRIMETHYLOLETHANE/ PROPIONALDEHYDE + FORMALDEHYDE (ALDOL, CANNIZARO)
9820-26	14	.	.	.	TRIMETHOXYBENZOIC ACID/ TRIBROMOBENZOIC ACID + DIMETHYLSULFATE
9820-27	E	1	.	.	TEG BOTTOMS/
9820-30	J	1	.	.	THIOPHENE/ BUTANE + SULFUR
9820-31	F1	1	.	.	TETRAHYDROTHIOPHENE/ THIOPHENE + HYDROGEN
9820-32	M	1	.	.	N-TETRADECYL MERCAPTAN/ ALPHA-OLEFIN +H2S
9820-33	24	.	1	.	TETRASODIUM ETHYLENEDIAMINE TETRAACETATE/ EDTA + CAUSTIC
9820-34	A	.	1	.	TRISODIUM NITRILOTRIACETATE,MONOHYDRATE/ NH3 + FORMALDEHYDE + NACN
9820-35	24	.	1	.	TRISODIUM NITRILOTRIACETATE SOLUTION/
9820-36	24	.	1	.	TRISODIUM N-HYROXYETHYLETHYLENEDIAMINE TRIACETATE/
9820-37	4	.	1	.	TETRASODIUM ETHYLENEDIAMINE TETRAACETATE/
9820-39	3	.	1	.	TRIAMINO CRYSTALS/
9820-45	G	1	.	.	TRI-OCTYL TRIMELLITATE/ ESTERIFICATION OF TRIMELLITIC ANHYDRIDE
9820-51	R	1	.	.	TRICHLOROPROPENE/ CHLORINATION - DEHYDROCHLORINATION OF PROPYLENE
9820-55	T	.	.	.	TERPHENYLS/ BENZENE THRU HOT TUBE

FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE	GEN_CODE	DIR	ZERO	UNK	PP_TEXT
9820-56	D1	1	.	.	TERATE RESINS/ POLYESTER
9820-57	5	1	.	.	TRIETHANOL AMMONIUM LAURYL SULFATE/ LAURYL AMINE + ETHYLENE OXIDE
9820-58	M	1	.	.	TRISODIUM SULFO SUCCINATE/ MALEIC ANHYDRIDE + SODIUM BISULFITE
9820-59	5	1	.	.	TRIETHANOLAMINE LINEAR ALKYLBENZENE SULFONATE/ ETHOXYLATION
9820-60	8	.	.	.	TAMOL (TRADE NAME) (POSSIBLY EPOXIDIZED SOYA OILS)
9820-62	F1	1	.	.	1,2,3,6 TETRAHYDROBENZALDEHYDE/ HYDROGENATION OF BENZALDEHYDE
9821-01	6	.	.	.	URAN (TRADE NAME)/ UREA DERIVATIVE
9821-04	A	1	.	.	URETHANE (MISC)/ ISOCYANATE + POLYOL
9822-01	G	1	.	.	VAZO(AZOBISISOBUTYRONITRILE)/ METHACRYLONITRILE + HYDRAZINE, DEHYDROGENATION
9822-02	D1	.	.	.	VARNISH RESIN (ROSIN AND ROSIN ESTERS)
9822-04	A	.	.	.	VOPITES (TRADE NAME) (URETHANE PREPOLYMERS)
9822-07	3	.	.	.	VULCANIZED FIBRE/
9822-08	E	.	1	.	VEGETABLE OILS-GENERAL/
9822-09	3	.	1	.	PRINTING INK VARNISHES/
9822-11	Q	1	.	.	N-VINYL-2-PYRROLIDONE/ 3-BUTYROLACTONE + ETHANOLAMINE, DEHYDRATION
9822-12	D1	1	.	.	VINYL-ACRYLIC SHEET/
9823-01	D1	.	4	.	WAX EMULSIONS/ FORMULATED FROM CAPTIVE FORMALDEHYDE - PHENOL, UREA, ETC RESINS
9823-02	3	.	1	.	WATERBORNE COATING/
9823-03	3	1	.	.	WOODFLOUR/
9823-05	4	.	1	.	WATER REPELLENT/
9824-01	8	.	1	.	XANTHATES OF C2-C5 ALCOHOLS/ ALCOHOLIC KOH + CS2
9825-01	3	1	.	.	SPUN YARN DRY PROCESS/
9826-01	A	.	1	.	ZINC AMMONIUM VERSENATE/ ETHYLENE DIAMINE + CHLOROACETIC ACID
9826-02	3	.	.	.	ZERANOL/
9826-04	24	.	.	.	ZINC UNDECYLENATE/ UNDECYLENIC ACID + ZINCOXIDE
9826-05	24	.	1	.	ZINC AND CALCIUM STEARATE/
9826-07	24	.	1	.	ZINC DISODIUM ETHYLENEDIAMINE TRIACETATE/
9901-01	3	6	3	.	AMMONIA/
9901-04	3	.	1	.	AMMONIUM NITRATE/
9901-05	3	3	.	.	AMMONIUM SULFATE/
9901-07	3	.	3	.	AMMONIA ANHYDROUS/RXN NITROGEN HYDROGEN
9901-08	3	1	.	.	ALUMINUM SULFATE/
9901-09	K	1	.	.	AMMONIUM SALTS-FATTY R-OH ETHER SULFATE/
9901-10	3	.	.	.	ALUMINUM FLUORIDE/
9902-02	3	1	.	.	BROMINE/
9903-02	3	1	1	.	CATALYST/
9903-03	3	8	2	.	CHLORINE-CAUSTIC/
9903-05	3	.	.	.	CURING AGENTS/
9903-09	3	.	.	.	CHLOROSULFONIC ACID/
9903-11	3	.	.	.	CHLORINATED DRY BLEACH/
9903-12	3	4	1	.	CARBON MONOXIDE/
9903-13	3	2	2	.	CAUSTIC SODA/
9903-14	3	1	.	.	CELLULOSE BATTERY SEPARATORS/

```
                    FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR   ZERO   UNK   PP_TEXT

9903-15       3         2     .      .    CALCIUM CHLORIDE/
9903-16       3         .     .      .    CALCIUM CARBIDE/
9903-18       3         .     1      .    CARBON DIOXIDE/
9903-19       3         .     .      .    CALCIUM HYDROXIDE/
9904-01       3         .     .      .    DIAMMONIUM PHOSPHATE/
9906-01       3         1     .      .    FLUORSPAR/
9908-02       3        11     3      .    HYDROCHLORIC ACID/
9908-03       3         5     5      .    HYDROGEN/
9908-04       3         1     .      .    HYDROFLOURIC ACID SALTS/
9908-07       3         1     .      .    HYDROGEN PEROXIDE/
9908-08       3         .     .      .    HYDROGEN SULFIDE/
9908-09       3         2     .      .    HYDROGEN CHLORIDE/
9908-10       3         2     .      .    HYDROGEN CYANIDE/
9909-02       3         1     .      .    INDUSTRIAL GASES-HYDROGEN NITROGEN/
9909-03       3         1     .      .    IODINE/
9912-01       3         .     .      .    LUDOX-SILICA/
9913-01       3         .     .      .    MIXED ACIDS (NITRIC & SULFURIC)/
9913-03       3         1     1      .    MURIATIC ACID (LOW GRADE HYDROCHLORIC ACID)/
9914-02       3         3     5      .    NITRIC ACID/
9914-04       3         .     .      .    NON-PIGMENTED PRODUCT/
9914-05       3         1     .      .    NITROGEN/
9915-01       3         2     1      .    OXYGEN/
9916-05       3         .     .      .    PHOSPHOROUS ACID/
9916-08       3         1     .      .    POLYSTYRENE (OPS) SHEET/
9916-12       3         1     .      .    POTASSIUM ACID PHTHALATE/
9916-20       3         .     .      .    PHOSPHOROUS PENTASULFIDE/
9916-21       3         .     .      .    POTASSIUM CARBONATE (POTASH)/BYPROD OF MSG (2080-99)
9917-01       6         .     .      .    QUARTERNARY AMMONIUM CHLORIDES/QUANTERNIZED DIMER DIAMINES,TETRAMINES
9919-02       3         .     1      .    SODIUM CHROMATE/
9919-04       3         2     .      .    SODIUM SULFATE/
9919-05       3         7     1      .    SULFURIC ACID/
9919-06       3         .     .      .    SODIUM NITRITE/
9919-08       3         .     .      .    SODIUM CHLORATE/
9919-10       3         .     .      .    SODIUM SILICATE/
9919-11       3         .     .      .    SYNTHESIS GAS/
9919-12       3         2     .      .    SODIUM METAL/
9919-15       3         1     .      .    SODIUM CARBONATE (NAOH + FLUE GAS)/
9919-16       3         .     .      .    SULFUR MONOCHLORIDE/
9919-17       3         .     .      .    SODIUM CHLORIDE/
9919-22       3         2     .      .    SODIUM HYPOCHLORATE/
9919-25       3         .     .      .    SULFUR (CRYSTEX)/
9919-26       3         1     .      .    SODIUM SALTS-FATTY ALCH ETHER SULFATE/
9919-31       3         1     .      .    SODIUM FERROCYANIDE/
```

```
              FREQUENCY OF OCCURRENCE FOR EACH PRODUCT PROCESS

PP_CODE    GEN_CODE    DIR    ZERO    UNK         PP_TEXT

9919-32        3        1      .       .      SULFUR ANHYDRIDE/
9920-01        3        1      .       .      TITANIUM DIOXIDE/
9923-01        3        1      .       .      WIRE AND CABLE/
9926-02        3        1      .       .      ZINC SULFATE/
```

APPENDIX B

BPT STATISTICS

BPT Statistical Appendix

DESCRIPTIVE STATISTICS

Some of the more commonly employed descriptive statistics are defined as follows:

(1) N - number of valid observations used in a particular analysis (e.g., the total number of effluent samples at a particular plant for a particular pollutant)

(2) Mean - arithmetic average: $\overline{X} = \sum_{i=1}^{N} X_i/N$

(3) Variance - standard unbiased estimate: $S^2 = \frac{1}{N-1} \sum_{i=1}^{N} (X_i - \overline{X})^2$

(The standard deviation is $S = \sqrt{S^2}$.)

(4) Minimum - the smallest value in a set of N observations

(5) Maximum - the largest value in a set of N observations

(6) Range - the minimum subtracted from the maximum

(7) Median - the middle value in a set of N observations. If N is odd (N = 2k - 1 for some integer k), the median is the kth order statistic, C(k). If N is even (N = 2k), the median is

$$1/2[C(k) + C(k + 1)].$$

MOVING STATISTICAL MEASURES

Over a year's data were available for some plants. The question of whether treatment system performance at those plants was consistent over time was investigated by examining moving statistical measures of performance. Let $X_1, \ldots, X_N$ denote the N daily observations available from a plant listed in the order they were obtained. Then the moving mean and variance on day t based on observations for the latest $n < N$ days are defined as

$$\overline{X}_t = \frac{1}{n} \sum_{i=1}^{n} X_{t-i+1}$$

and

$$S_t^2 = \frac{1}{(n-1)} \sum_{i=1}^{n} (X_{t-i+1} - \overline{X}_t)^2,$$

where $t \geq n$.

If the distribution of X is lognormal (so $\log_e(X)$ is normal with parameters μ and σ^2), then the 99th percentile of X is

$$P99 = e^{\mu + 2.326\sigma}$$

The moving estimate of P99 at time t based on the lognormal model, therefore, is

$$P99_t = e^{\overline{X}_t + 2.326S_t}$$

with $\overline{X}_t$ and S_t^2 defined above.

Moving estimates of the 99th percentiles of effluent concentrations were plotted over time for each plant to evaluate the consistency of its treatment performance (see Appendix D). Note that the moving 99th percentile will reflect changes in both average effluent levels (through $\overline{X}_t$) and day-to-day effluent variation (through S_t).

GOODNESS-OF-FIT TESTS

The statistical model used to describe effluent data assumes that $y = \log(C)$ is normally distributed, where C is the daily effluent BOD or TSS concentration. Goodness-of-fit tests for this model were run using the studentized range test based on the statistic

$$U = R/S,$$

with the range (R) and standard deviation (S) defined above. Critical values of the U-test are given in Biometrika Tables for Statisticians, Vol. 1, page 200, for selected sample sizes (N). An upper tail test was used to guard against alternative distributions with heavier tails than the lognormal distribution; the lognormal model would tend to underestimate the 99th percentile if such alternatives were appropriate.

A significance level of $\alpha = 0.01$ was employed in each test. Since there were a total of 28 data sets tested (17 for BOD and 11 for TSS), this choice of α ensured that the overall probability of rejecting the lognormal model, when it was appropriate, was reasonably small.

Table B-1 shows the results of the goodness-of-fit tests. The model was rejected for only two out of twenty-eight data sets (BOD for plant 236 and TSS for plant 27). The impact on the 99th percentile estimate for the two rejected cases was evaluated by comparing model-based estimates with nonparametric estimates; namely, the next to largest of the 162 BOD observations and the next to the largest of the 158 TSS observations. For BOD at plant 236, the model gave P99 = 93 versus the nonparametric estimate of P99 = 70. For TSS at plant 27, the model gave P99 = 76 compared to the nonparametric estimate of P99 = 80. In neither case was the lognormal estimate substantially lower than the nonparametric estimate.

The goodness-of-fit of the lognormal model also was checked through a graphical procedure called a probability plot. Let $X_1, \ldots, X_n$ denote the n observed daily values of the parameter of interest (the BOD or TSS measurements from a given plant). Denote the rth largest of the n values by $X_{(r)}$, and define a corresponding score called the "probit" by

$$\text{Probit}[X_{(r)}] = \Phi^{-1}[r/(n + 1)],$$

where $\Phi^{-1}(\cdot)$ is the inverse of the standard normal cumulative distribution function. The probit score is the normal deviation (z-value) equivalent to the value $X_{(r)}$. Probit scores are useful because plots of X values versus corresponding probit scores tend to be straight lines when X is normally distributed; this fact is the basis for probability plots. If X has a lognormal distribution, a log-scale plot of X values versus probit scores tends to be a straight line. Daniel and Wood (1971) give simulated examples of probability plots to indicate the degree of random departure from a straight line to expect for different sample sizes when X is normally distributed. Probability plots for BOD and TSS are presented in Figures B-1 to B-28.

Based on the results of the studentized range test and the probability plots, it was concluded that the lognormal distribution could be used to model the data.

TABLE B-1. GOODNESS-OF-FIT TESTS FOR BOD AND TSS
LOG_e OF DAILY DATA

PLANT	TYPE	BOD			TSS		
		N	U	P*	N	U	P*
9	P	24	4.84	N.S.	24	3.73	N.S.
15	NP	363	6.97	N.S.	0	-	-
27	NP	160	5.77	N.S.	158	7.36	<0.01
44	P	261	5.86	N.S.	260	6.00	N.S.
45	P	156	4.03	N.S.	364	3.86	N.S.
96	P	105	3.96	N.S.	66	4.83	N.S.
110	NP	247	4.73	N.S.	218	4.70	N.S.
111	P	157	4.36	N.S.	347	5.69	N.S.
113	NP	332	5.77	N.S.	91	4.45	N.S.
118	NP	365	4.52	N.S.	0	-	-
126	P	249	5.09	N.S.	253	5.49	N.S.
170	NP	103	3.21	N.S.	0	-	-
175	NP	361	4.98	N.S.	0	-	-
220	NP	55	3.92	N.S.	149	5.22	N.S.
234	NP	157	5.71	N.S.	0	-	-
236	NP	162	7.28	<0.01	362	6.43	N.S.
281	NP	203	5.22	N.S.	0	-	-

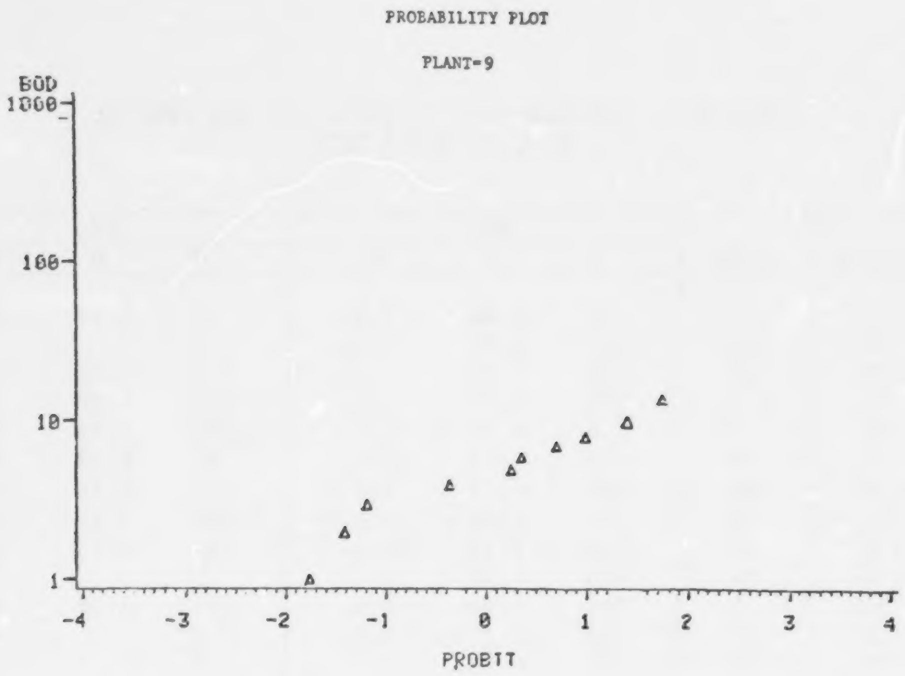
---

* Critical values for the studentized range test (upper tail, $\alpha = 0.01$) are

N	$U_{.99}$
25	5.06
50	5.77
65	6.01
90	6.27
100	6.36
150	6.64
200	6.84
500	7.42

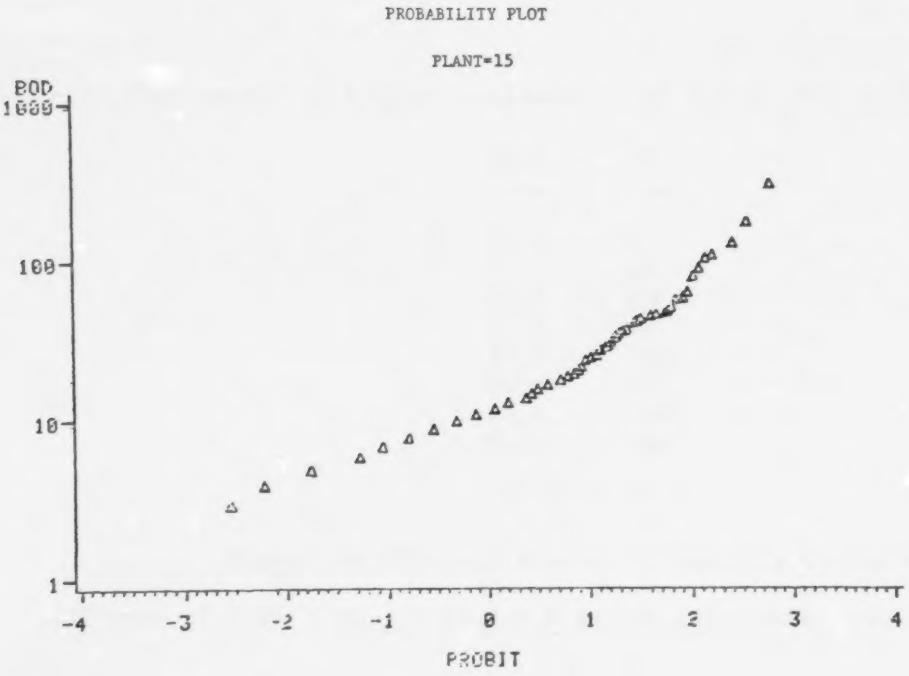
N.S. = Not significant (U value below critical level).

Reference: Biometrika Tables for Statisticians, Vol. 1, page 200.


PROBABILITY PLOT

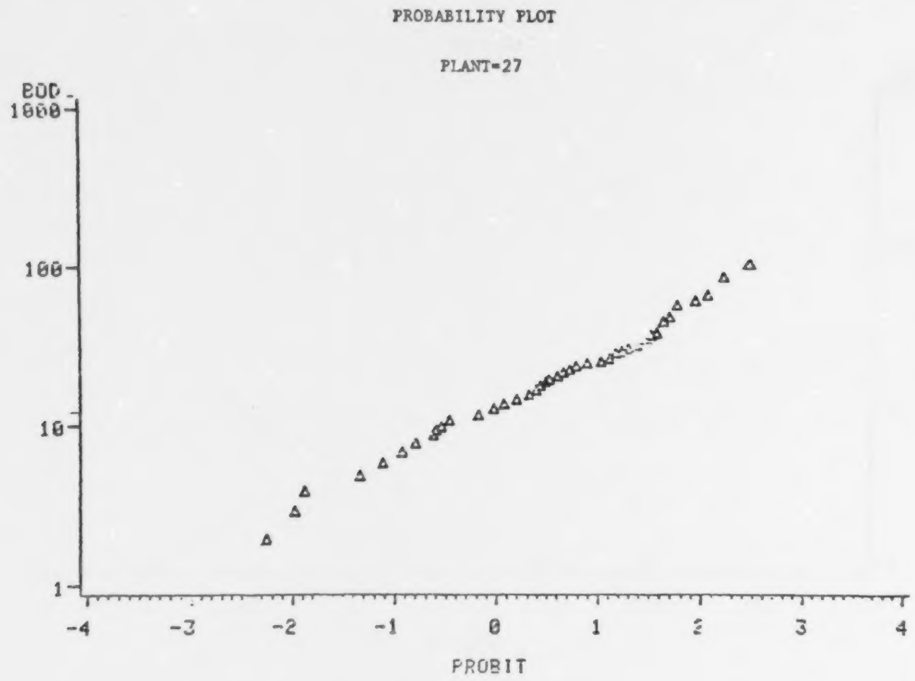
PLANT=9

FIGURE B-1. PROBABILITY PLOT FOR BOD


PROBABILITY PLOT

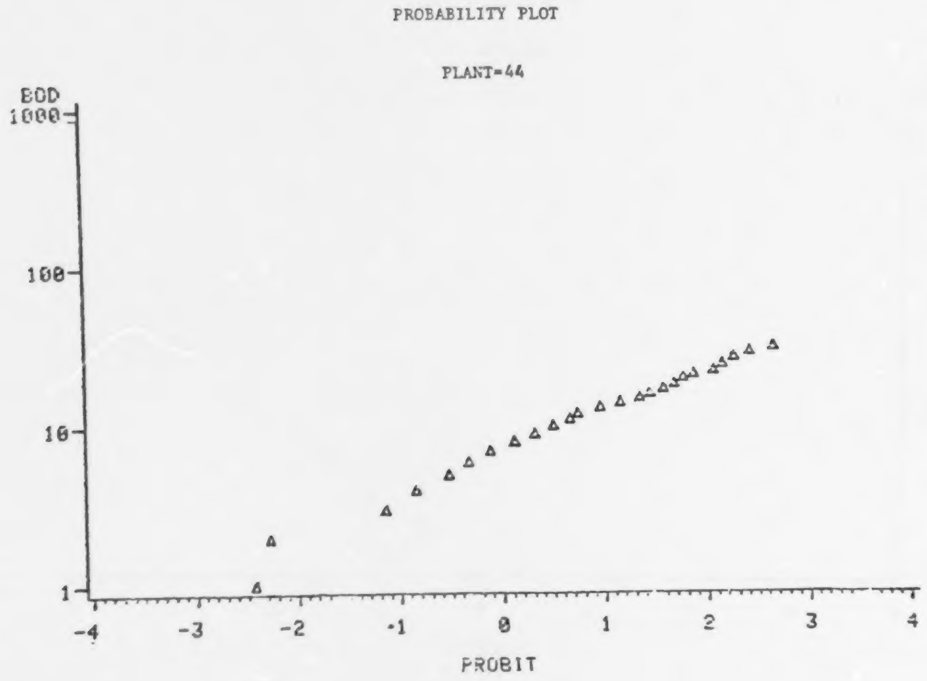
PLANT=15

FIGURE B-2. PROBABILITY PLOT FOR BOD


PROBABILITY PLOT

PLANT=27

FIGURE B-3. PROBABILITY PLOT FOR BOD


PROBABILITY PLOT

PLANT=44

FIGURE B-4. PROBABILITY PLOT FOR BOD

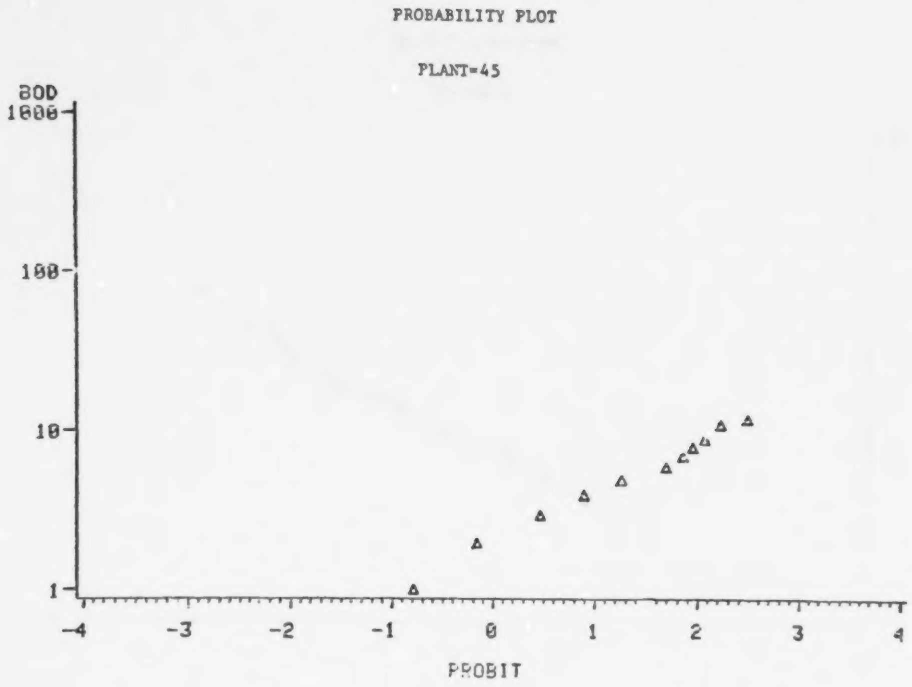


FIGURE B-5. PROBABILITY PLOT FOR BOD

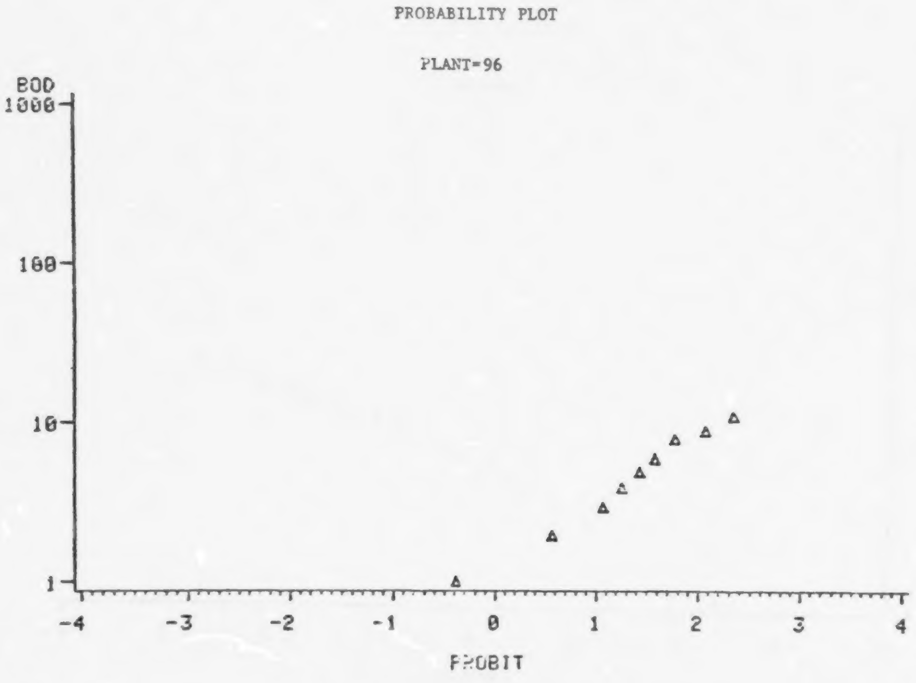


FIGURE B-6. PROBABILITY PLOT FOR BOD

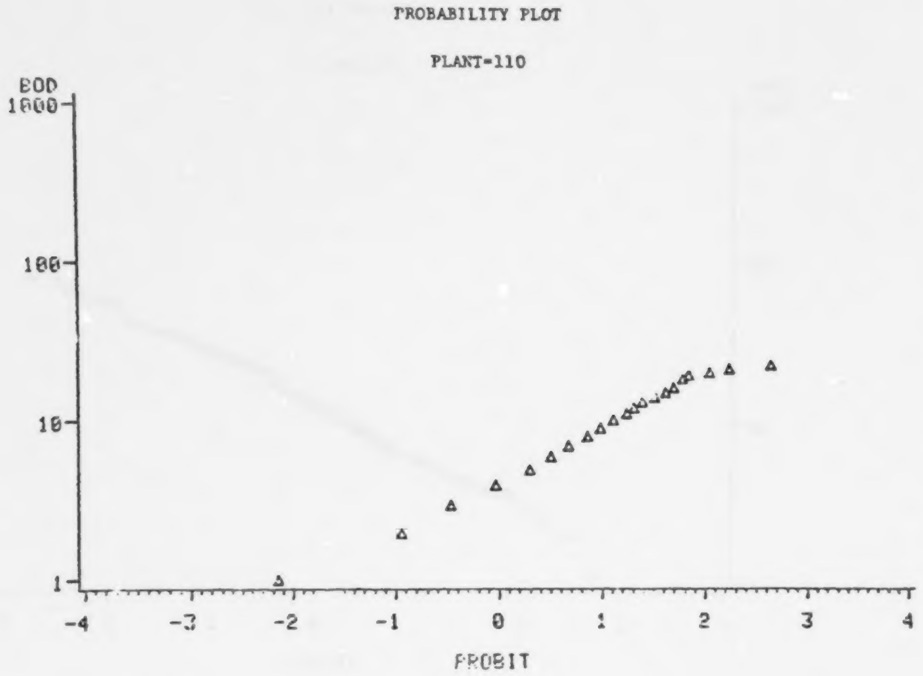


FIGURE B-7. PROBABILITY PLOT FOR BOD

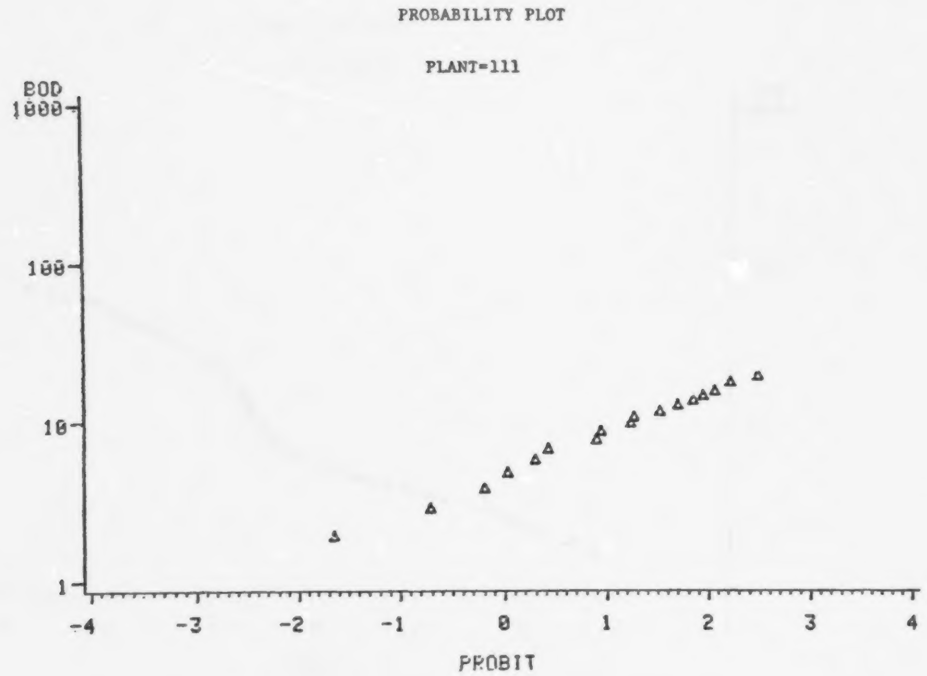


FIGURE B-8. PROBABILITY PLOT FOR BOD

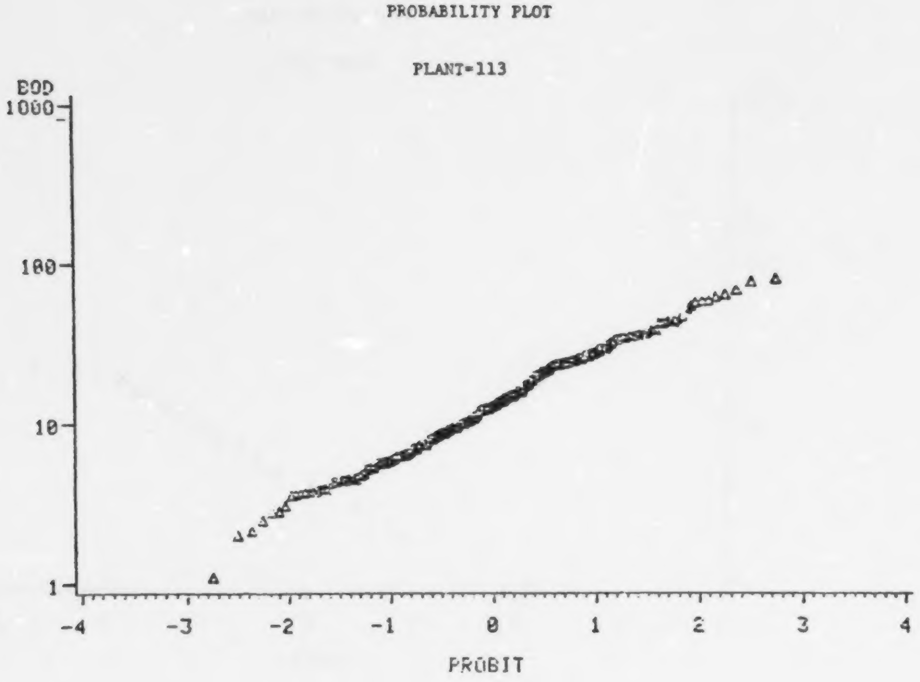


FIGURE B-9. PROBABILITY PLOT FOR BOD

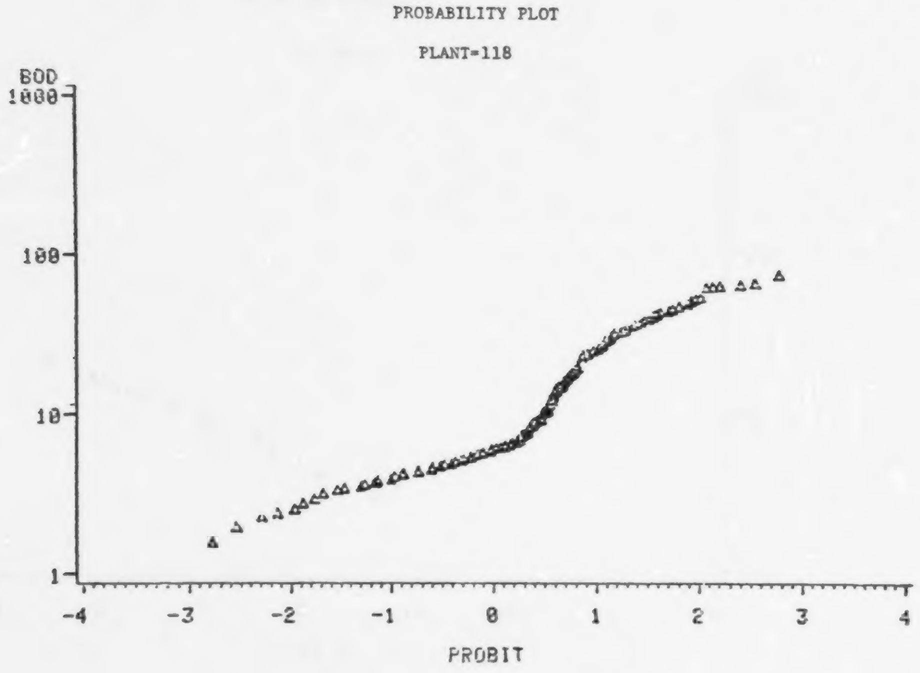


FIGURE B-10. PROBABILITY PLOT FOR BOD

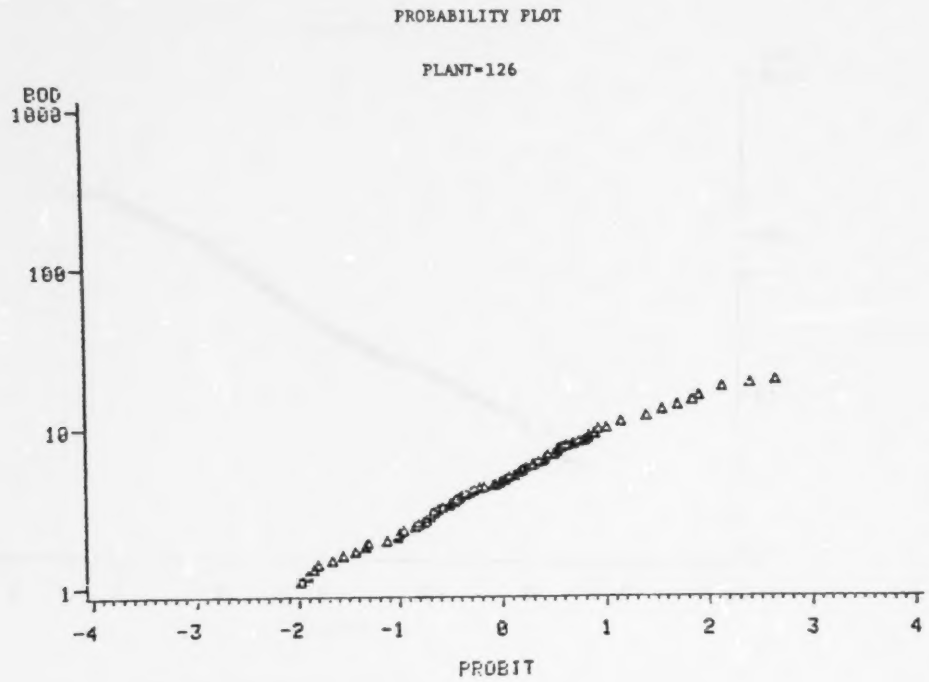


FIGURE B-11. PROBABILITY PLOT FOR BOD

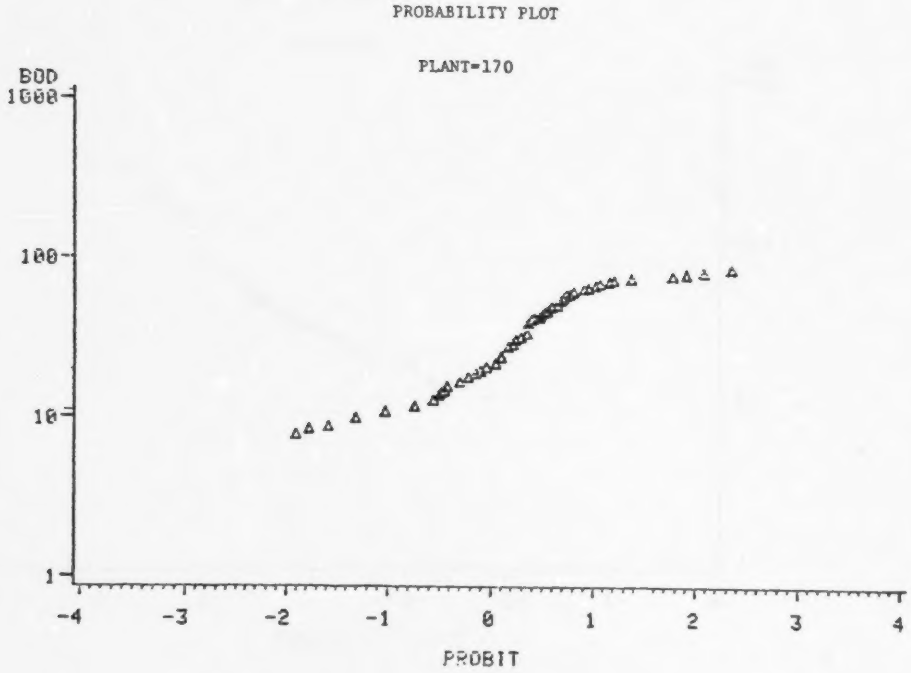


FIGURE B-12. PROBABILITY PLOT FOR BOD

PROBABILITY PLOT

PLANT=175

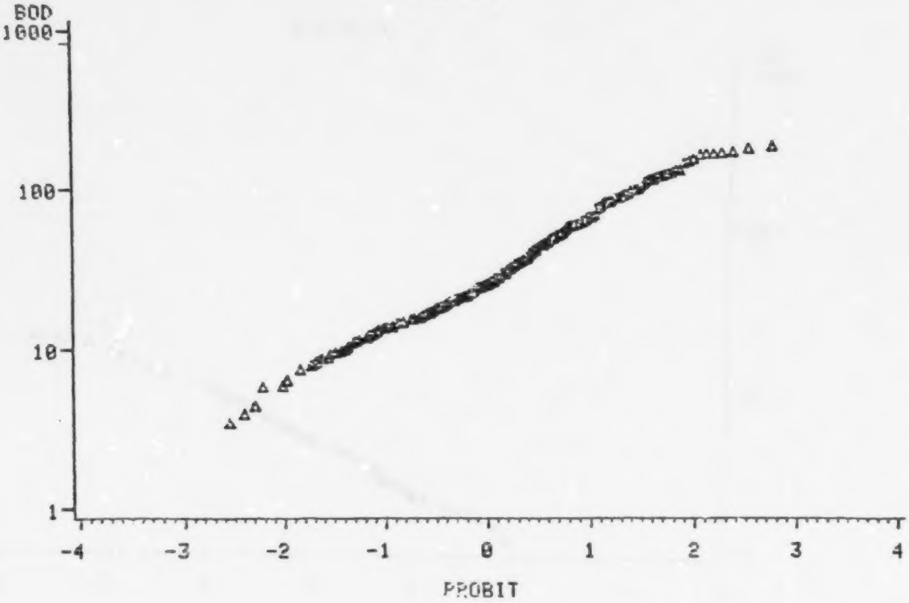


FIGURE B-13. PROBABILITY PLOT FOR BOD

PROBABILITY PLOT

PLANT=220

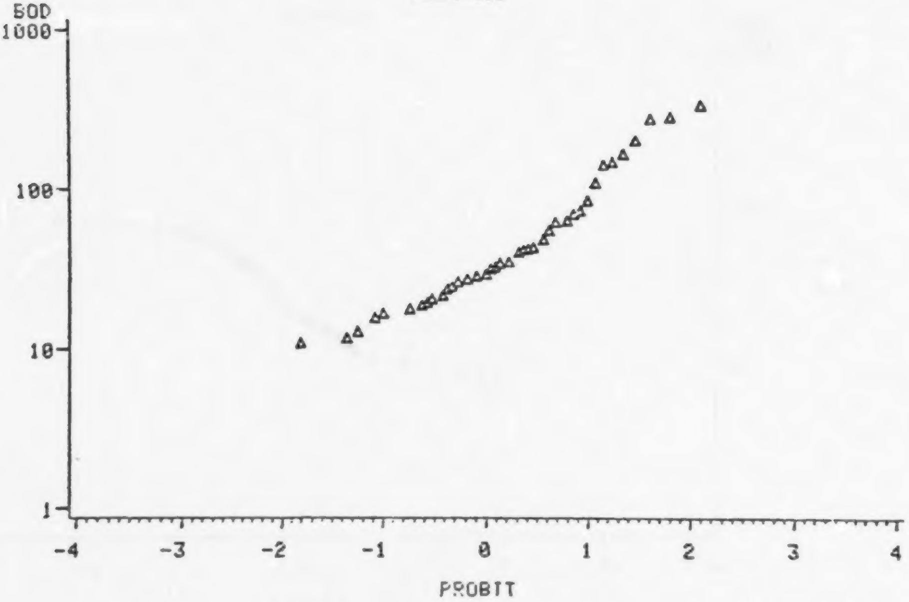


FIGURE B-14. PROBABILITY PLOT FOR BOD

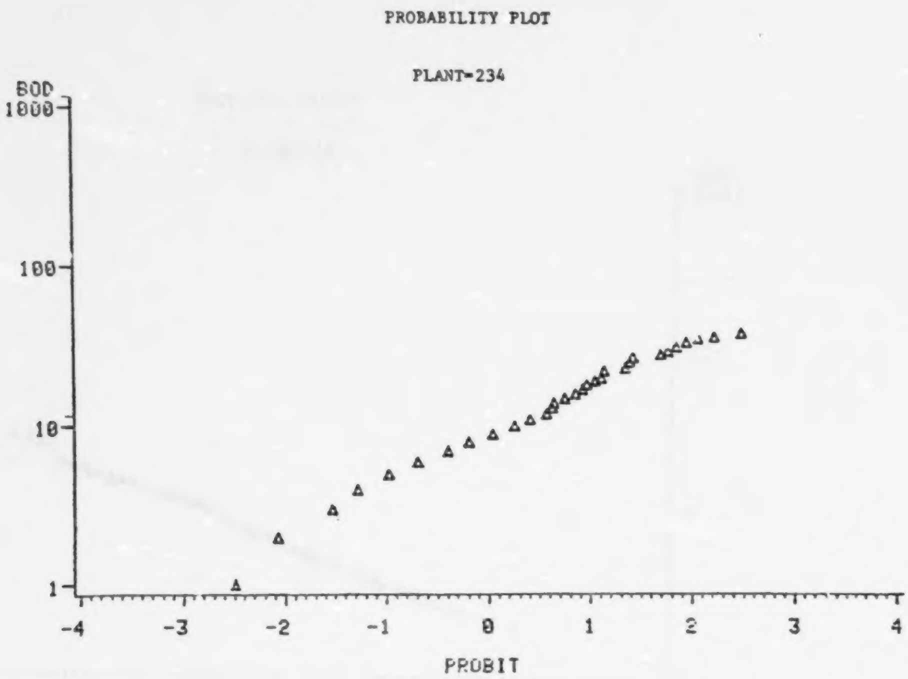


FIGURE B-15. PROBABILITY PLOT FOR BOD

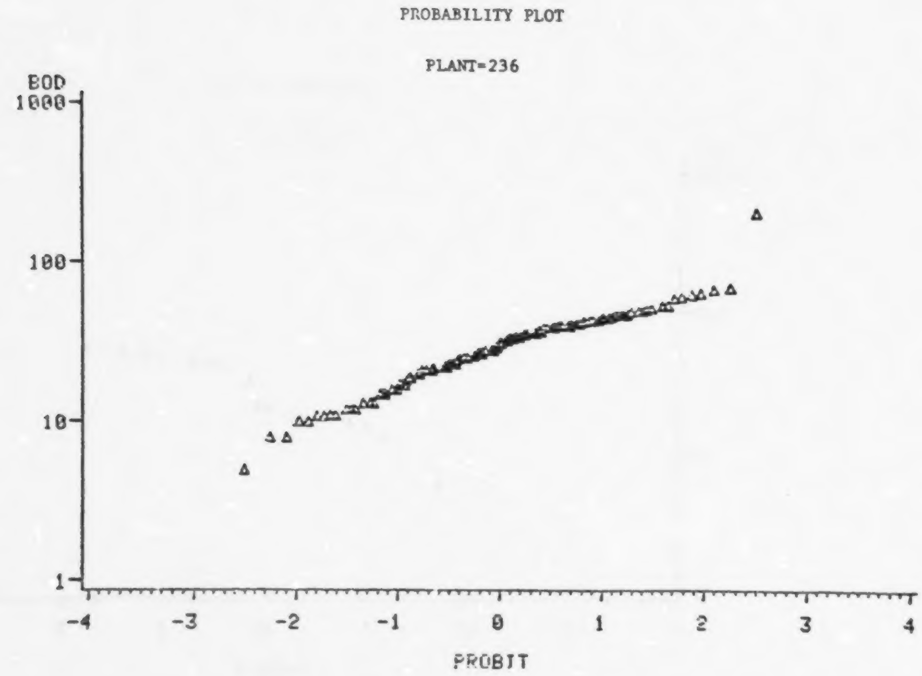


FIGURE B-16. PROBABILITY PLOT FOR BOD

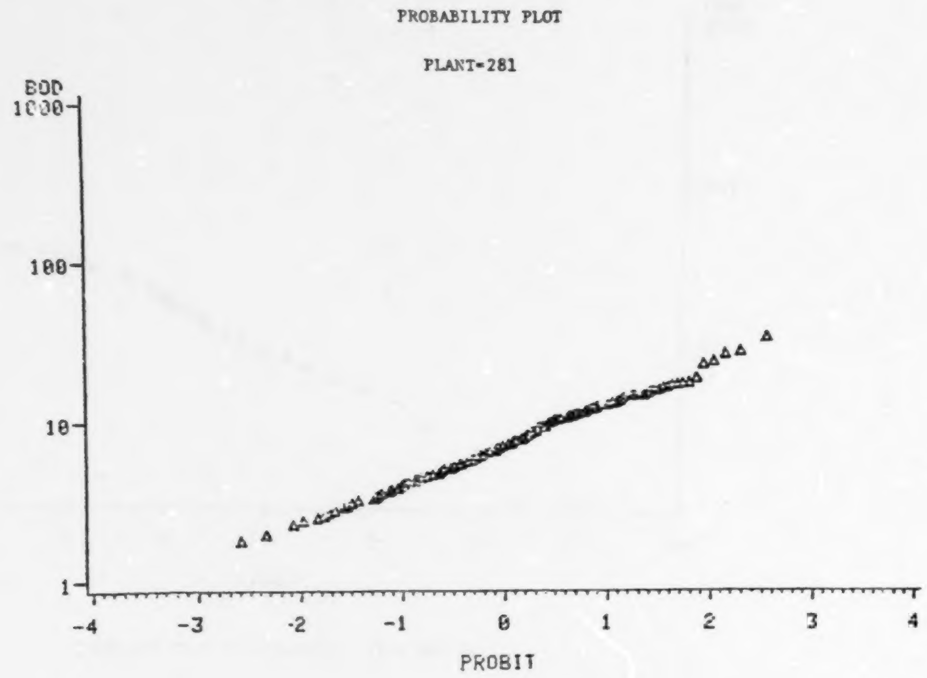


FIGURE B-17. PROBABILITY PLOT FOR BOD

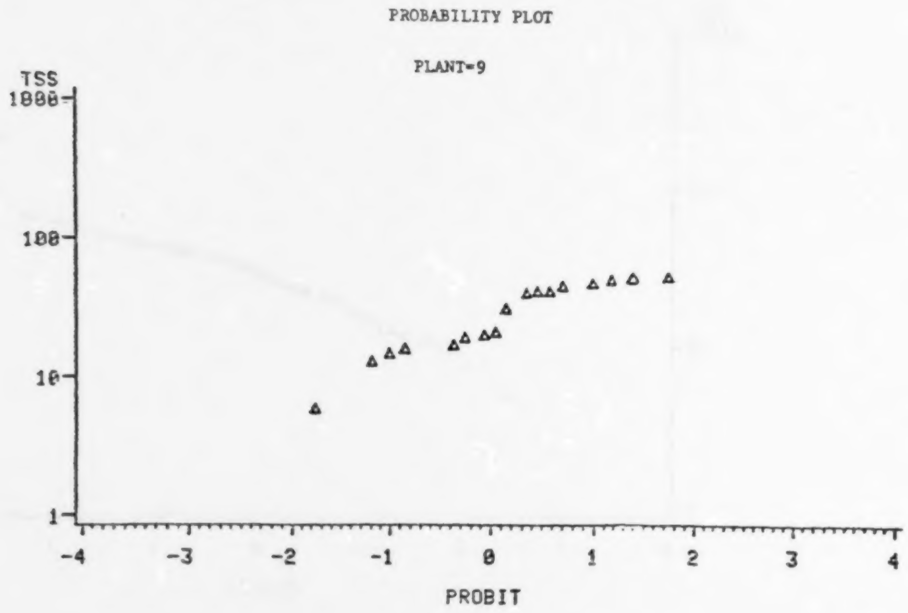


FIGURE B-18. PROBABILITY PLOT FOR TSS

PROBABILITY PLOT

PLANT=27

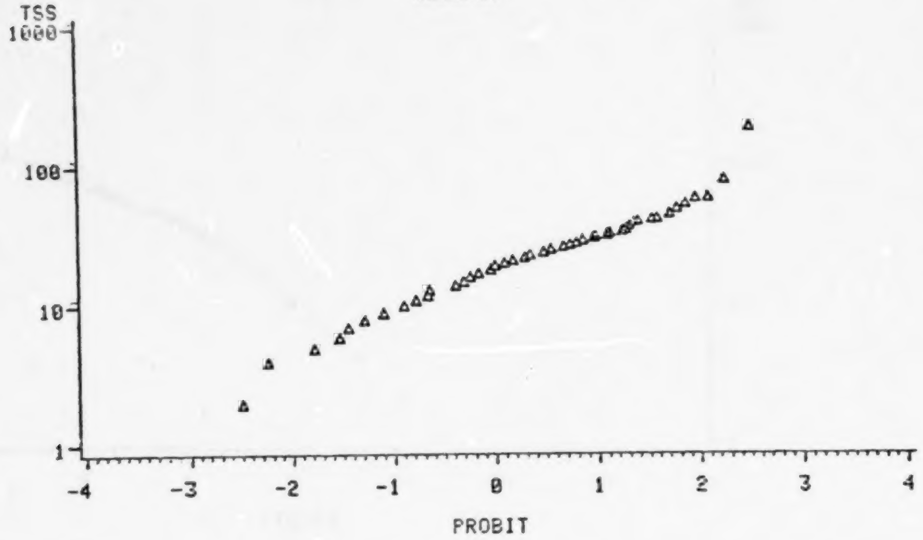


FIGURE B-19. PROBABILITY PLOT FOR TSS

PROBABILITY PLOT

PLANT=44

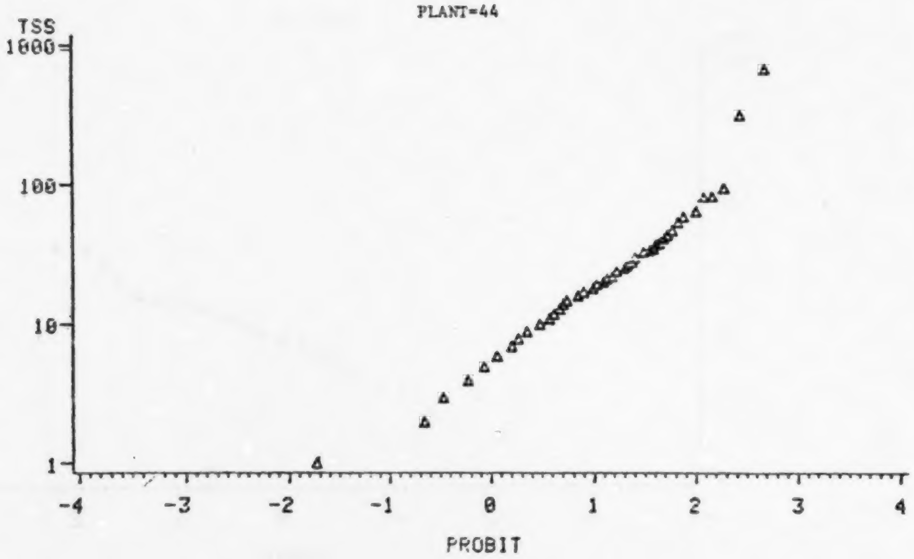


FIGURE B-20. PROBABILITY PLOT FOR TSS

PROBABILITY PLOT

PLANT=45

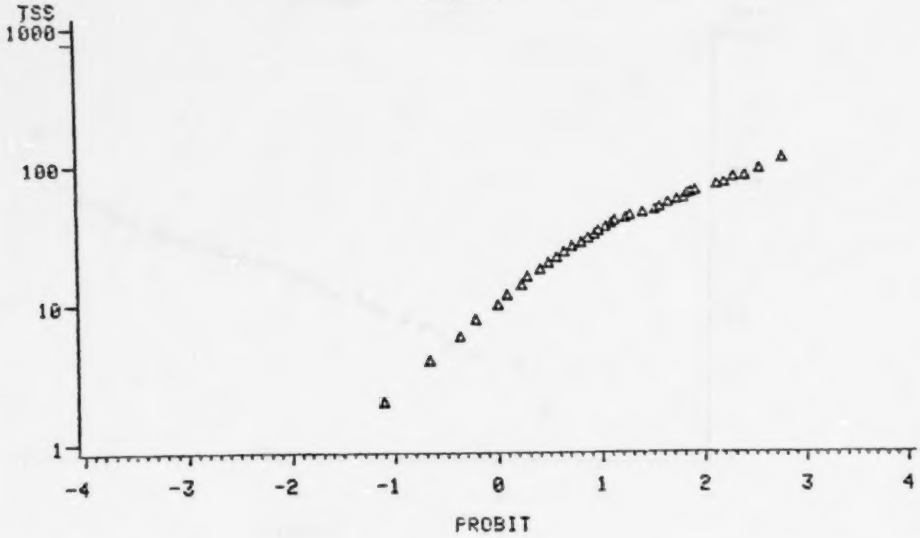


FIGURE B-21. PROBABILITY PLOT FOR TSS

PROBABILITY PLOT

PLANT=96

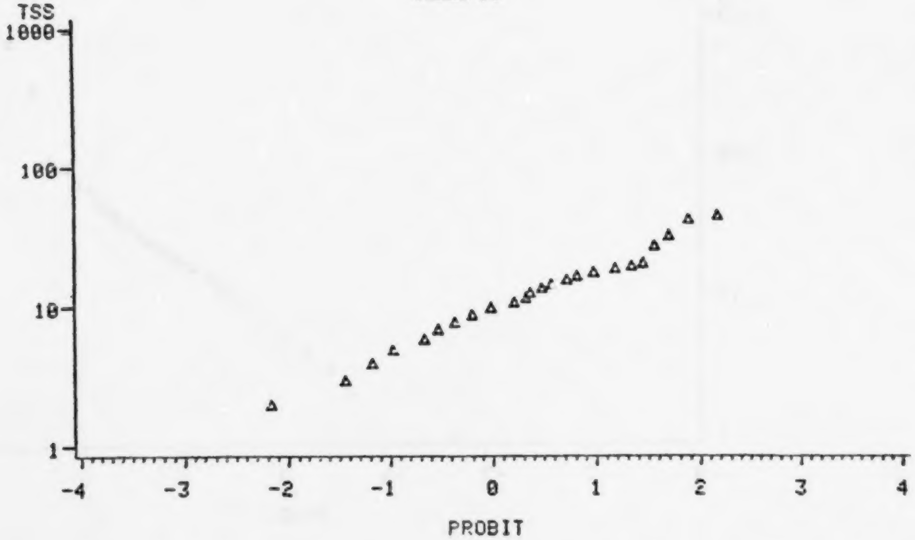


FIGURE B-22. PROBABILITY PLOT FOR TSS

PROBABILITY PLOT

PLANT=110

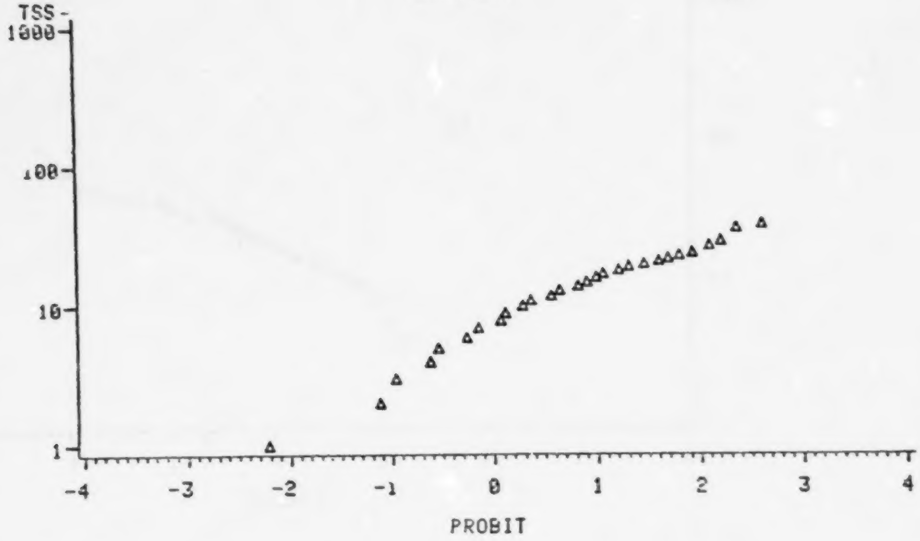


FIGURE B-23. PROBABILITY PLOT FOR TSS

PROBABILITY PLOT

PLANT=111

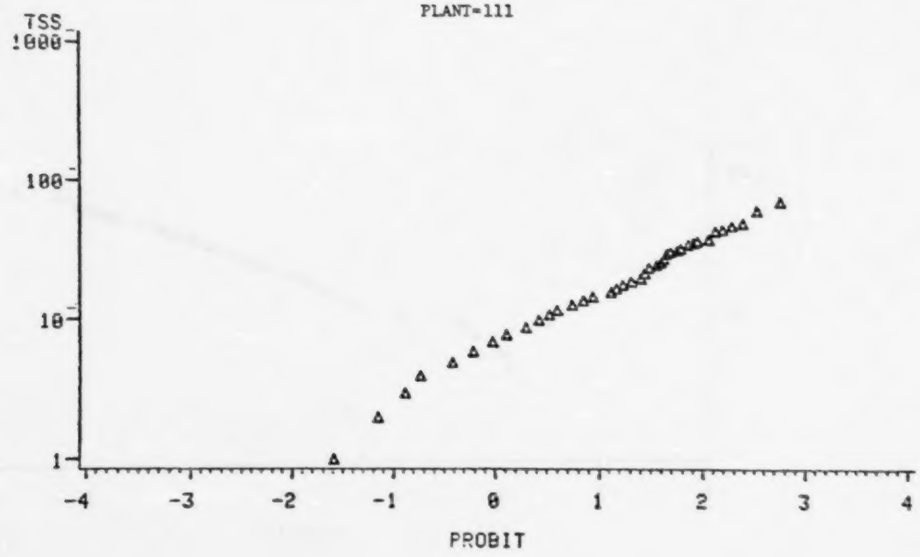


FIGURE B-24. PROBABILITY PLOT FOR TSS

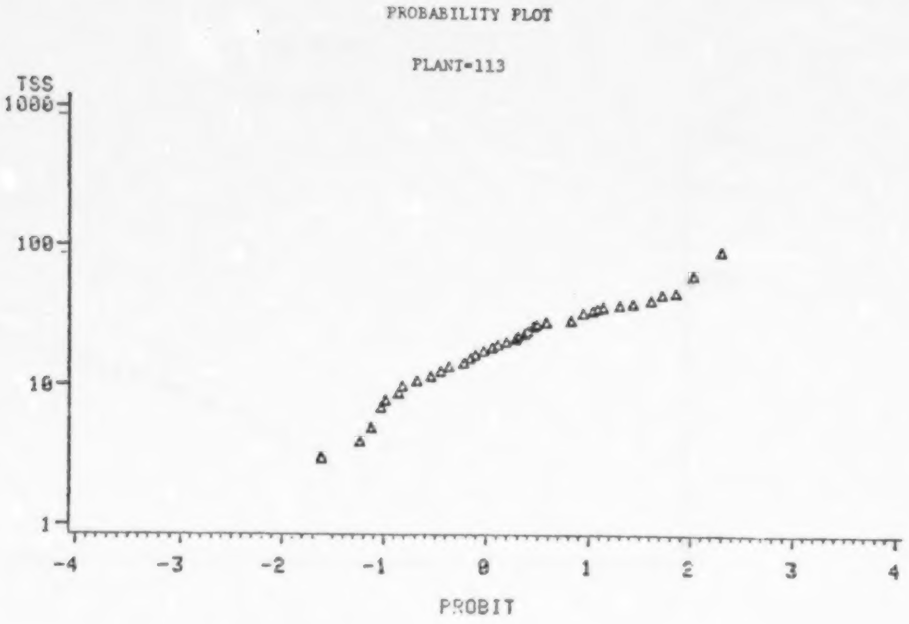


FIGURE B-25. PROBABILITY PLOT FOR TSS

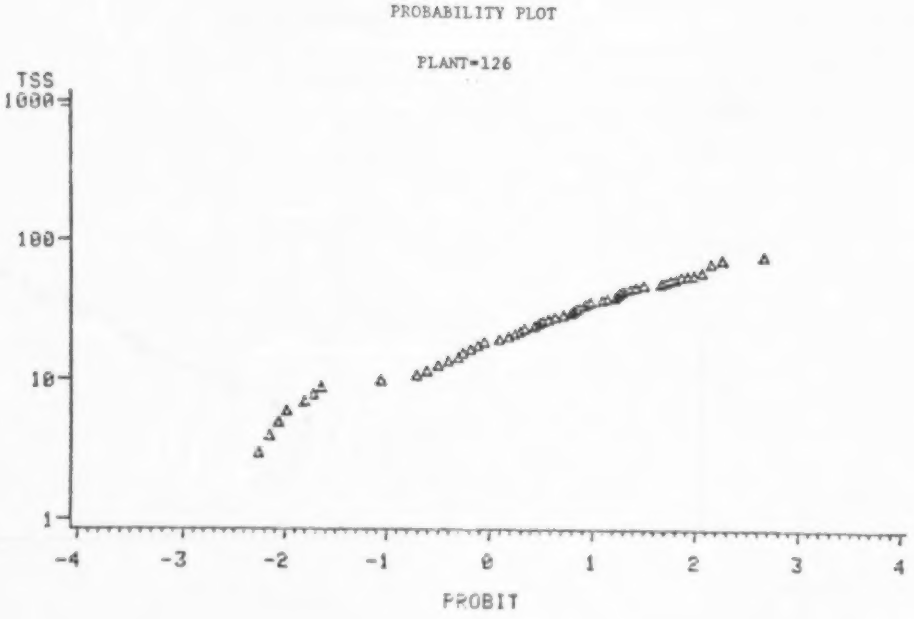


FIGURE B-26. PROBABILITY PLOT FOR TSS

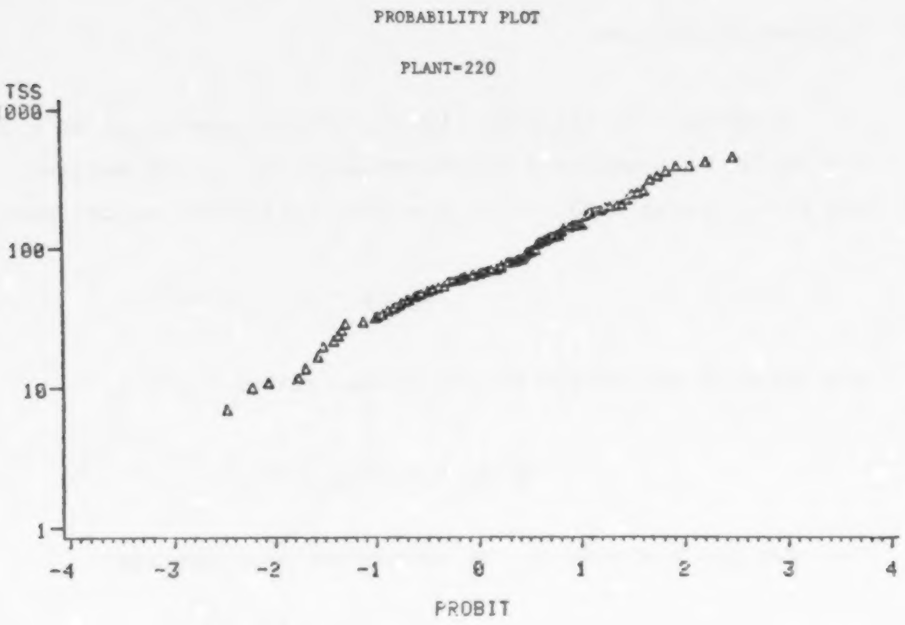


FIGURE B-27. PROBABILITY PLOT FOR TSS

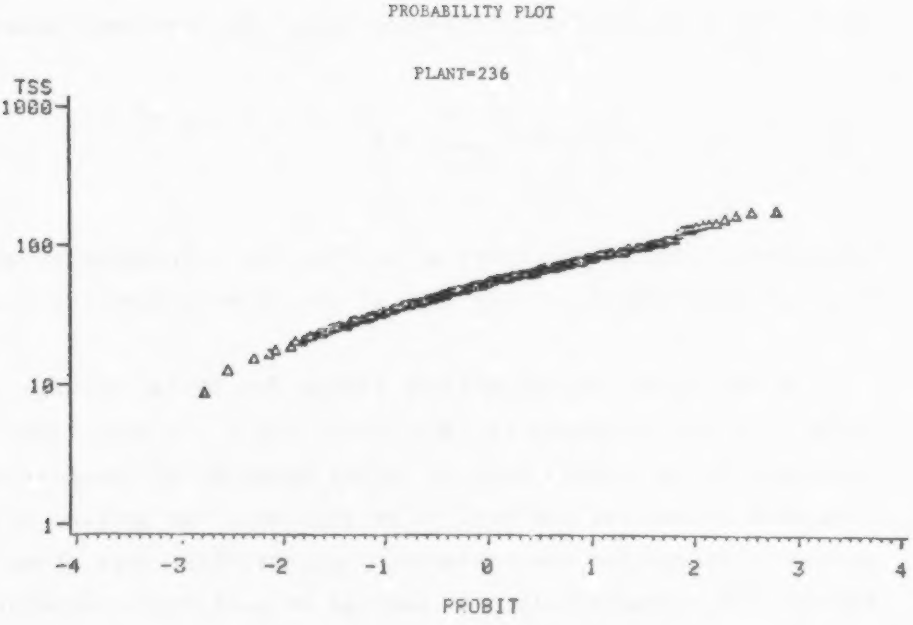


FIGURE B-28. PROBABILITY PLOT FOR TSS

VARIABILITY FACTORS

Assuming that the distribution of the concentration c is lognormal, then $y = \log(c)$ is normally distributed with mean μ and variance σ^2 (Aitchison and Brown, pages 8-9). Thus the 99th percentile on the natural log scale is

$$y_{0.99} = \mu + 2.326\,\sigma\ ,$$

and the 99th percentile on the concentration scale is

$$c_{0.99} = \exp(y_{0.99}) = e^{\mu + 2.326\,\sigma}\ . \qquad (1)$$

The mean and variance on the concentration scale are:

$$\mu_c = e^{\mu + 1/2\,\sigma^2}$$

and

$$\sigma_c^2 = e^{2\mu + \sigma^2}\,(e^{\sigma^2} - 1).$$

Hence, the daily variability factor under the lognormal model is:

$$VF(1) = \frac{c_{0.99}}{\mu_c} = e^{2.326\,\sigma - 1/2\,\sigma^2} \qquad (2)$$

Estimates of any of the above quantities are calculated by substituting the mean and variance of natural logs of the observations for μ and σ^2, respectively.

To determine the variability factor for 30-day average concentrations, VF(30), it was necessary to take day-to-day correlation into account. Positive autocorrelation between concentrations measured on consecutive days means that such concentrations tend to be similar. The medians of plant-specific autocorrelations for one-day-apart concentrations were about 0.7 and 0.4 for BOD and TSS, respectively. An average of positively correlated concentration measurements is more variable than an average of independent concentrations.

A rigorous time series analysis to model the autocorrelation structure of each data set was not possible because of the many missing days' data in most data sets. Therefore, the correlation (ρ) between consecutive days' measurements (i.e., the lag-1 autocorrelation) was estimated for each plant using the available data. Then using the first-order autoregressive model commonly found to be appropriate in water pollution modeling, the mean and variance of an n-day average were approximated by:

$$\mu_{\bar{c}} = e^{\mu + 1/2\ \sigma^2} \tag{3}$$

and

$$\sigma_c^2 = \frac{\sigma_c^2}{n}\ fn(\rho) \tag{4}$$

with

$$fn(\rho) = \frac{1 + \rho}{1 - \rho} - \frac{2\ \rho\ (1 - \rho^n)}{n(1 - \rho)^2}\ .$$

It can be seen in (4) that σ_c^2 equals the variance of an average of n uncorrelated observations, σ_c^2/n, times a factor $fn(\rho)$ that adjusts for the presence of autocorrelation. The correlation-adjustment factor is derived as follows using the fact that the covariance between concentrations k days apart is $\rho^k\ \sigma_c^2$ under the first-order autoregressive model. Since

$$\bar{c} = \frac{1}{n} \sum_{i=1}^{n} c_i,$$

$$\sigma_c^2 = \frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} cov(c_i, c_j)$$

$$= \frac{1}{n^2} [n \sigma_c^2 + 2 \sum_{k=1}^{n-1} (n - k) \rho^k \sigma_c^2]$$

$$= \frac{\sigma_c^2}{n} [\frac{2}{n} \sum_{k=0}^{n-1} (n - k) \rho^k - 1].$$

The expression in brackets reduces to fn(ρ) with the help of the summation formula for arithmetico-geometric progressions:

$$\sum_{k=0}^{n-1} (a + kr)q^k = \frac{a - [a + (n - 1)r]q^n}{1 - q} + \frac{rq(1 - q^{n-1})}{(1 - q)^2} ,$$

taking $a = n$, $r = -1$, and $q = \rho$ (Gradshteyn and Ryzhik, page 1).

Finally, since $\bar{c}$ is approximately normally distributed by the Central Limit Theorem, the 95th percentile and variability factor of a 30-day average are approximately

$$\bar{c}_{0.95} = \mu_{\bar{c}} + 1.645 \sigma_{\bar{c}} \tag{5}$$

and

$$VF(30) = \bar{c}_{0.95}/\mu_{\bar{c}}$$

$$= 1 + 1.645[(e^{\sigma^2} - 1)f_{30}(\rho)/30]^{1/2} \tag{6}$$

with $\mu_{\bar{c}}$ and $\sigma_{\bar{c}}^2$ defined by equations (3) and (4). Estimates of $\bar{c}_{0.95}$ or VF(30) are calculated by substituting estimates of μ, σ^2, and ρ into the formulas above.

SPEARMAN RANK CORRELATION TECHNIQUE

Let $(X_1, Y_1), (X_2,Y_2),\ldots,(X_n,Y_n)$ be a bivariate random sample of size n. The rank of X_i, $R(X_i)$, as compared with the other X values, for $i = 1,2,\ldots,n$ is the position of X_i as the X values are ordered from smallest to largest. Thus, if X_k is the smallest X value, $R(X_k) = 1$ and if X_l is the largest X value, $R(X_l) = n$. Similarly the values for Y can be ranked for $i = 1,2,\ldots n$. Once ranked, the data can be replaced with the rank pairs $(R(X_1),R(Y_1))$, $(R(X_2), R(Y_2)),\ldots,(R(X_n),R(Y_n))$. The Spearman rank correlation coefficient is calculated as follows:

$$R = \frac{\sum_{i=1}^{n} R(X_i)R(Y_i) - [1/2\ (n+1)]^2}{\frac{n(n^2-1)}{12}}$$

Based on R the following hypothesis can be tested:

H_o: The X_i and Y_i are mutually independent (i.e., their correlation is zero)

H_1: Either (a) there is a tendency for the larger values of X to be paired with the larger values of Y, or (b) there is a tendency for the smaller values of X to be paired with the larger values of Y.

By using influent or effluent concentrations for the X's and subcategorization variables for the Y's, the above hypothesis becomes a statistical test for significant subcategorization factors. Throughout this chapter the term "null hypothesis" refers to the hypothesis H_o: the X_i and Y_i are mutually independent.

Aside from the fact that a rank correlation statistically tests whether two variables are independent, it also does not assume a linear relationship between the variables. Consider Table B-2, where X and Y are two variables that exhibit a nonlinear relationship. The Pearson correlation coefficient, r, which assumes a linear relation between X and Y, is 0.6, where

$$r = \sum_i (X_i - \overline{X})(Y_i - \overline{Y})/[\sum_i (X_i - \overline{X})^2 \sum_j (Y_j - \overline{Y})^2]^{1/2}$$

$$\overline{X} = \frac{1}{n} \sum_i X_i$$

$$\overline{Y} = \frac{1}{n} \sum_i Y_i$$

while the nonparametric Spearman Rank Correlation coefficient, R between R(X) and R(Y), is 1. Correlation coefficients are numbers which range between -1 and +1. Values of ± 1 indicate perfect associations or correlations, while a value of zero indicates no relationship.

For each of the rank correlation coefficients calculated, a graph has been attached which plots the rank pairs $(R(X_i), R(Y_i))$. A least squares line has been superimposed on the plot of the rank pairs to indicate graphically the degree of correlation. Each graph is labeled with the appropriate industry subcategory (e.g., Plastics Only).

At the bottom of each figure is the Spearman rank correlation coefficient, the sample size N, and the probability, p, that the null hypothesis, H_o, is true. Values of p of less than 0.05 indicate that a relationship exists, as specified in the alternative hypothesis, H_1. For ease of interpretation, Figures B-29 through B-33 show the theoretical lines for a sample size of 50 and Spearman rank correlations of -1, -0.5, 0, 0.5, and 1, respectively. As can be seen from these graphs, correlations of -1 and -0.5 indicate that as R(Y) decreases, R(X) increases; a correlation of 0 indicates that no relationship exists between R(X) and R(Y); and correlations of 0.5 and 1 indicate

TABLE B-2. AN EXAMPLE OF VARIABLES WITH A NONLINEAR RELATIONSHIP

X	Y	R(X)	R(Y)
1	1	1	1
10	1.5	2	2
20	2	3	3
25	4	4	4
30	10	5	5
35	50	6	6
50	70	7	7
100	90	8	8
200	95	9	9
600	100	10	10

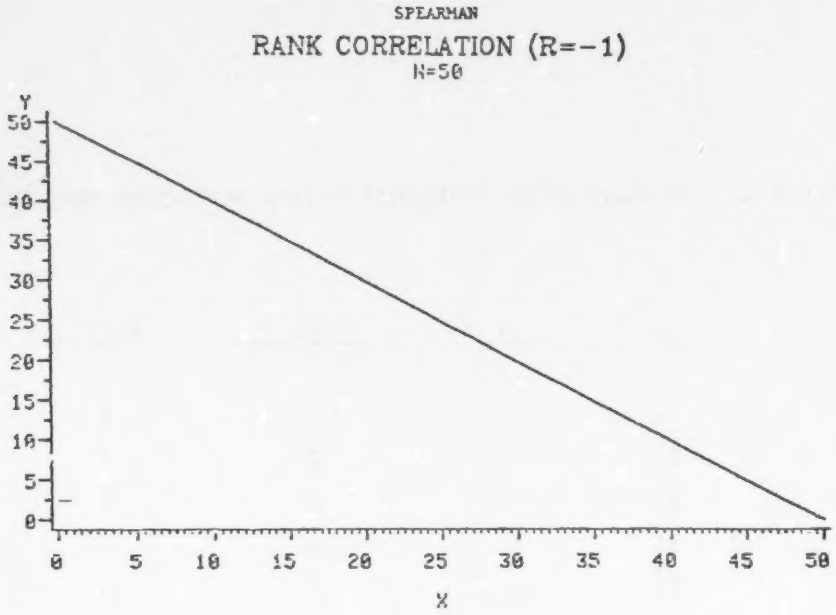


FIGURE B-29. REGRESSION LINE FOR RANK CORRELATION OF -1

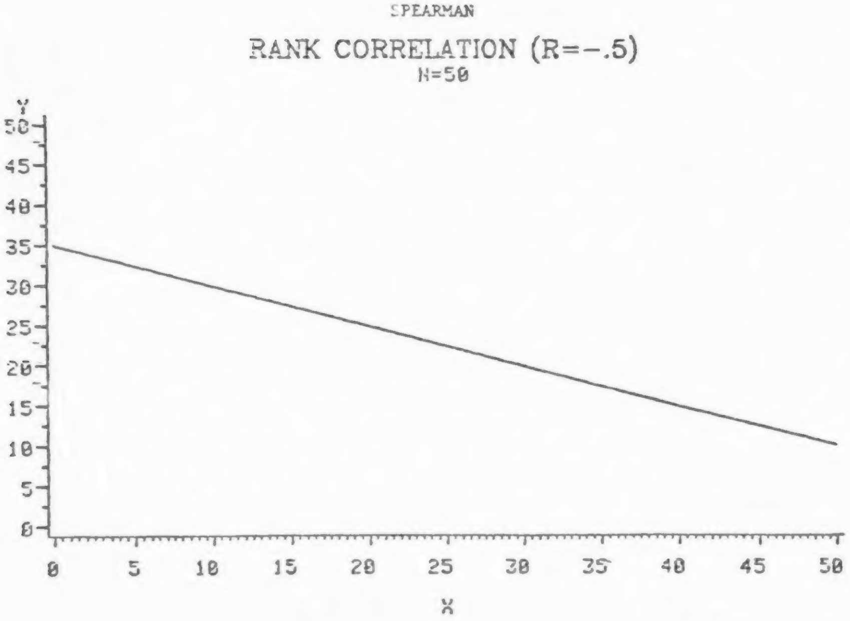


FIGURE B-30. REGRESSION LINE FOR RANK CORRELATION OF -0.5

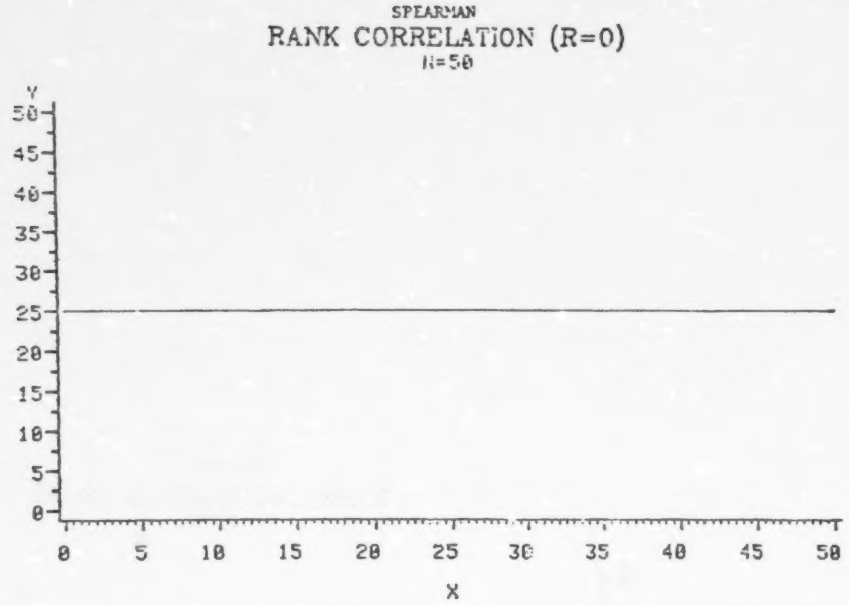


FIGURE B-31. REGRESSION LINE FOR RANK CORRELATION OF 0

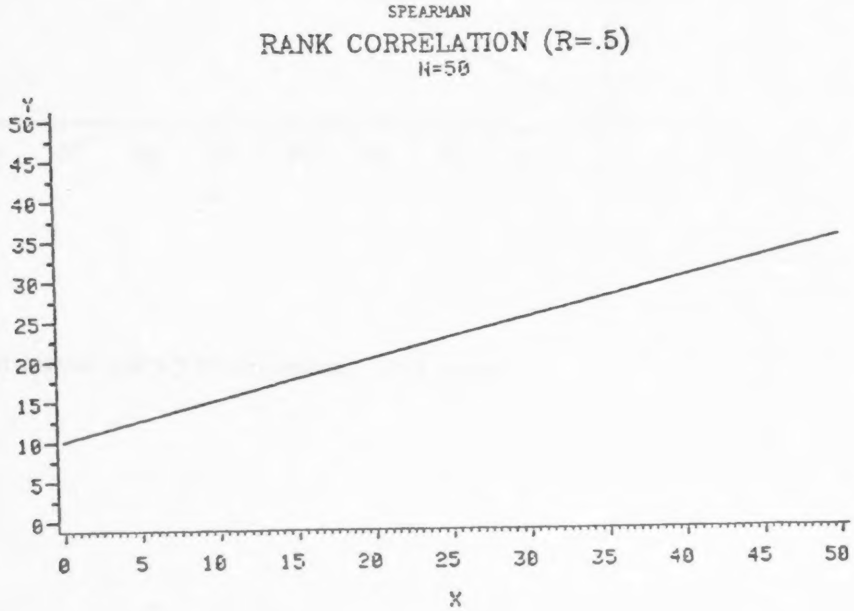


FIGURE B-32. REGRESSION LINE FOR RANK CORRELATION OF 0.5

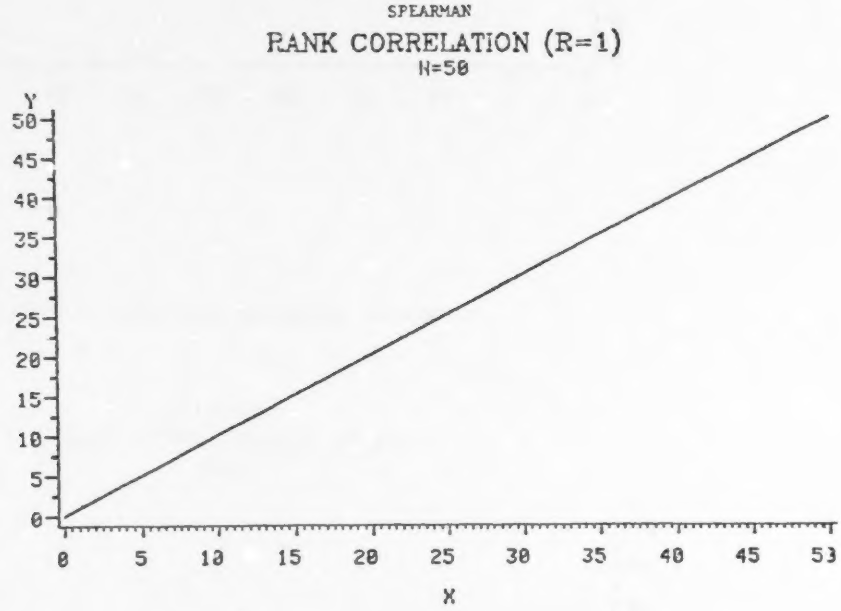


FIGURE B-33. REGRESSION LINE FOR RANK CORRELATION OF 1 that as R(Y) increases, R(X) increases. It should be noted that the Spearman rank coefficient only indicates a dependent relationship between R(X) and R(Y). Derivation of the functional relationship between X and Y requires additional statistical techniques.

TERRY-HOEFFDING TEST

A common problem in statistics is the "two-sample problem" in which two populations are compared based on random samples of observations from each. This is precisely the problem one faces when trying to determine subcategories for a guideline: if two populations are different, then they represent different subcategories. For example, a statistical test which shows that Plastic plants' influent BOD levels are different from those of Not Plastic plants demonstrates the need for separately analyzing Plastic and Not Plastic plants.

In statistical terms, the problem is to test the null hypothesis that two population distributions have the same mean or median value of a property of interest. Random samples of sizes n_1 and n_2 are taken from the populations, a test statistic is computed from the sample data, and the value of the test statistic is used to decide whether the null hypothesis of identical population distributions should be rejected.

The most commonly used test for differences between population means is the two-sample Student's t test. Let $y_i(i = 1,\ldots,n_1)$ and $z_i(i = 1,\ldots,n_2)$ represent the sample observations from the two populations. Then Student's t statistic is

$$t = (\bar{y} - \bar{z})/s \sqrt{n/n_1 n_2}, \tag{7}$$

where

$$n = n_1 + n_2$$

is the pooled sample size,

$$\overline{y} = \frac{1}{n_1} \sum_{i=1}^{n_1} y_i$$

and

$$\overline{z} = \frac{1}{n_2} \sum_{i=1}^{n_2} z_i$$

are the sample means, and

$$s^2 = (n-2)^{-1} [\sum_{i=1}^{n_1} (y_1 - \overline{y})^2 + \sum_{i=1}^{n_2} (z_i - \overline{z})^2]$$

is the pooled sample variance. The observed value of the t statistic is compared to tabled critical values of the t distribution with n-2 degrees of freedom to determine whether to reject the null hypothesis of equal population means.

The t test assumes that the population values are normally distributed with equal variances. When either of these assumptions fails to hold, conclusions of the test may be invalidated. One problem that may result is that the null hypothesis may be rejected with higher probability than assumed when it actually is true (i.e., the probability of a Type 1 error (α) may exceed the nominal α-level). Another possible problem is that the t test may fail to detect existing population differences as well as it would if the assumptions held (i.e., its statistical power may be reduced). Either of these problems would have unfortunate consequences in subcategorization: false rejection of the null hypothesis could lead to unnecessary subcategories; failure to detect differences could result in failure to recognize needed subcategories. In order to avoid incorrect conclusions that could be caused by failing to satisfy the assumptions behind the t test, a different test based on less restrictive assumptions was used.

The Terry-Hoeffding test corresponds closely to the two-sample t test, but it assumes only that observations are drawn randomly from two continuous population distributions. For large samples, the Terry-Hoeffding test can be thought of as a two-sample t test based on "normal scores" rather than on the original observations. That is, before performing the t test, one replaces the rth largest observation in the pooled sample of n observations with the expected value of the rth largest observation from a random sample of size n from a standard normal distribution (E(r, n)). For large n, it is convenient to approximate normal scores by

$$E(r, n) \doteq \Phi^{-1}[r/(n + 1)], \qquad (8)$$

since the inverse of the cumulative normal distribution function, $\Phi^{-1}(\cdot)$, is readily available in computer systems. For small n, values of E(r, n) are tabled in nonparametric statistics books (e.g., Bradley, page 326). The intuitive idea of the Terry-Hoeffding test is that replacing original observations (which may not be normally distributed) with normal scores leads to a more robust test (one whose validity is not as limited by underlying assumptions).

Because the sum of normal scores for the pooled sample is zero, the t statistic based on normal scores simplifies to

$$t = \sqrt{n-2}\, S / \left[\frac{n_1 n_2}{n} \sum_{r=1}^{n} E(r,n)^2 - S^2 \right]^{1/2}, \qquad (9)$$

where S is the sum of normal scores for the sample with fewer observations (Bradley, page 152). The observed value of t is compared to critical values of the t distribution with n-2 degrees of freedom (just like the classical t test). A simpler approximation to this test for large samples is based on comparing

$$T = \left[\frac{n-1}{n_1 n_2} \right]^{1/2} S \qquad (10)$$

to critical values of the standard normal distribution (the mathematical justification for this approximation is given in Kendall and Stuart). For small samples, the Terry-Hoeffding test compares observed values of S to tabled critical values. Bradley (pages 327-330) gives critical values of S for pooled sample sizes up to n = 20.

The Terry-Hoeffding test has several advantages over the classical t test:

- It is distribution-free; i.e., one need not be concerned that violations of distributional assumptions will affect the probability of a Type I error.
- Its large-sample power is better except when the normality assumption holds (then, it is equivalent to the t in large sample power)
- It is less sensitive to extreme observations (outliers) than the t. For example, the actual value of the largest observation in the pooled sample doesn't affect the Terry-Hoeffding test, but can have a great impact on the classical t test.

Kendall and Stuart (page 520) note that it is "difficult to make a case for the customary routine use of Student's test" in comparing two populations when the sample numbers are reasonably large.

To illustrate the application of the Terry-Hoeffding test, the hypothetical influent BOD data from Plastics and Not Plastics plants in Table B-3 will be used. The table gives original observations and normal scores for ten Plastics plants and fourteen Not Plastics plants (the normal scores were calculated using formula (8)). The null hypothesis is that Plastics and Not Plastics plants do not differ in median influent BOD. The sum of normal scores for plastics plants is

TABLE B-3. EXAMPLE OF SAMPLE DATA FOR THE TERRY-HOEFFDING TEST

RANK (r)	BOD	SOURCE*	NORMAL SCORE (E(r,n))
1	150	P	-1.751
2	170	P	-1.405
3	190	P	-1.175
4	210	P	-0.994
5	230	P	-0.842
6	250	P	-0.706
7	270	P	-0.583
8	320	NP	-0.468
9	370	NP	-0.358
10	420	P	-0.253
11	470	P	-0.151
12	520	NP	-0.050
13	550	P	0.050
14	590	NP	0.151
15	610	NP	0.253
16	630	NP	0.358
17	680	NP	0.468
18	730	NP	0.583
19	780	NP	0.706
20	800	NP	0.842
21	810	NP	0.994
22	870	NP	1.175
23	930	NP	1.405
24	990	NP	1.751

*P = Plastics
NP = Not plastics

$$S = -7.81,$$

so the test statistic based on formula (10) is

$$T = -3.71.$$

Since this is less than -1.96, the critical value for the normal distribution with $\alpha = 0.05$ for a two-tailed test, we reject the null hypothesis at this α-level. That is, we conclude that Plastics plants are different from Not Plastics plants in the example. Note in Table B-3 that observed BOD values (and normal scores) for Plastics tend to be lower than values for Not Plastics.

REFERENCES

Aitchison, J., and J.A.C. Brown (1957). The Lognormal Distribution, Cambridge University Press, London, 8-9.

Bradley, J.V. (1968). Distribution-Free Statistical Tests, Prentice-Hall, Englewood Cliffs, NJ, 149-154, 326-330.

Daniel, C., and F.S. Wood (1971). Fitting Equations to Data, Wiley, New York, 34-43.

Gradshteyn, I.S., and I.W. Ryzhik (1965). Tables of Integrals, Series and Products, Academic Press, New York, 1.

Kendall, M.G., and A. Stuart (1973). The Advanced Theory of Statistics, Vol. 2, 3rd Edition, Hafner, New York, 516-520.

Pearson, E.S., and H.O. Hartley (1969). Biometrika Tables for Statisticians, Vol. 1, 3rd Edition, Cambridge University Press, London, 200.

APPENDIX C

See Chapter 13 of the BAT Volume of this report for the glossary.

APPENDIX D

Rationale for Exclusion of Daily Data Base Plants From Variability Analysis

APPENDIX D

Rationale For Exclusion of Daily Data Base Plants From Variability Analysis

Plant No. 1: The plant upgraded its treatment system significantly during the first data period and since the second data collection period, and no data are available for the upgraded plant. The aerated lagoons were converted to activated sludge in 1980. In addition, the effluent daily data for both periods included unqualified cooling water dilution. Plant personnel expressed doubts as to available data's validity.

Plant No. 3: The treatment system for this plant was upgraded significantly during the data collection period. The aerated lagoons were replaced by activated sludge units after August 1976. In addition, the plant had operational problems from July 1978 to February 1980, including clarifier shutdowns, clarifier floodings and difficulties with the equalization basins, which make the data unrepresentative of a steady-state operation.

Plant No. 292: This plant is not considered representative of Organic Chemical Industry plants due to the inclusion of municipal effluent in its influent. The municipal flow may be as much as 25 percent of the total influent, and therefore is considered a significant, and atypical, influent stream.

Plant No. 18: During the data collection period, this plant underwent major expansion and modification. Screening, equalization, increased capacity, chlorination facilities and sludge handling facilities were implemented in 1976. Available data are, therefore, not considered to be from a steady-state system. Also, the effluent sample point is upstream of the final clarifiers, and therefore not representative of actual plant performance.

Plant No. 293: This plant is a poor performer (BOD removal 89%, effluent BOD 87 mg/l). Available information indicates poor solids control may be the cause of poor performance (TSS removal 66%).

Plant No. 20: No BOD, COD or TSS effluent data are available for this plant.

Plant No. 24: No BOD, COD, or TSS data are available for this plant.

Plant No. 28: The treatment system of this plant does not conform to accepted engineering practice. In particular, the use of chlorination before trickling filters is noted as being extremely unusual, and not in accordance with accepted wastewater treatment methodology.

Plant No. 42: The poor performance by this plant seems to be related to poor operational procedures. Flow is reported to be alternated between two equalization lagoons, with the switch between the two noted as a cause for high effluent BOD. Steady-state operation is also reported to be interrupted by periodic sludge wasting from the anaerobic lagoon.

The treatment train used at this plant (anaerobic lagoon followed by activated sludge) is unorthodox. Plant was zero discharge until 1978. The data period is therefore shortly after startup and may not represent steady-state operations.

Plant No. 53: The treatment system for this plant has been upgraded and no data are available for the upgraded system. Plant had aerated lagoons, but they were inadequate for loadings received. The plant was converted to activated sludge in 1977 in order to improve solids control (effluent TSS 74 mg/l).

Plant No. 60: This plant achieved poor treatment levels (BOD removal 88%, effluent BOD 54 mg/l).

Plant No. 61: This plant has upgraded its treatment system due to poor performance, and no data are available for the upgraded system. Increased pretreatment, neutralization and dual media filters were added in 1977 in order to improve poor (BOD removal 79%, effluent BOD 81 mg/l) plant performance. (Available information indicates that insufficient air supply to aeration basins and poor solids control may have been responsible for the poor performance noted during the data period.)

Plant No. 72: There are no continuous data for this plant available at present.

Plant No. 73: This plant phased out a major production unit during collection period, which resulted in an estimated 70 percent reduction in influent BOD load from 12/75 through 12/76. Thus, the available data are not for a system operating under steady state conditions.

Plant No. 74: The data available for this plant are not representative of actual treatment system performance. The available effluent daily data include an unquantified stormwater stream. In addition, no BOD, TSS or COD data are available; only TOC and flow data were reported.

Plant No. 75: The data available for this plant are not representative of actual treatment system performance. The available effluent daily data include an unqualified waste stream which consists of untreated boiler blowdown, stormwater runoff and cooling water. No daily data are available for this stream.

Plant No. 87: For this plant, the effluent sampling site was downstream from a mixing point of biological and nonbiological effluents (i.e., effluent is diluted). Also, no BOD or TSS data are available for this plant.

Plant No. 89: The data available for this plant do not accurately represent actual treatment plant performance. The effluent daily data include an unquantified stream which consists of untreated process water and stormwater runoff. No daily data are available for this stream.

Plant No. 90: The data available for this plant are not representative of actual treatment plant performance. Available effluent daily data include an unquantified stream consisting of untreated cooling water. No daily data are available for the cooling water stream.

Plant No. 103: No effluent BOD, COD or TSS data are available for this plant.

Plant No. 106: Effluent data for this plant contain cooling water dilution. This data is therefore not representative of actual treatment plant performance.

Plant No. 109: Data available for this plant are not representative of actual treatment plant performance. Effluent data contain dilution by an unqualified wastestream for which only estimated average BOD is reported.

Plant No. 120: This plant treats petroleum refinery wastewater as well as organic chemical wastewater, and is therefore not representative of treatment plants in the OCPS data base.

Plant No. 123: Data available for this plant are not representative of actual treatment plant performance. Available effluent data include stormwater dilution.

Plant No. 124: The data avilable for this plant are not representative of actual treatment plant performance. The available effluent data include an unquantified stream consisting of untreated stormwater. No daily data are available for the stormwater stream.

Plant No. 138: This plant achieved poor removals during the period for which data are available. (Effluent BOD 251 mg/l.) This appears to be caused by inadequate treatment system design. In particular, the lack of final clarification is noted.

Plant No. 146: Data available for this plant are not representative of actual treatment plant performance. Available effluent data include stormwater dilution.

Plant No. 176: There are only three months of data available for this plant.

Plant No. 245: This plant has been rejected due to the use of a nonbiological (air stripping) treatment system.

Plant No. 268: This plant was found to have high effluent BOD (248 mg/l) and BOD removal below 95% (93% BOD removal).

Plant No. 269: The treatment system of the plant has been upgraded and no data are available for the upgraded system. Additions to the plant in 10/77 included primary settling, equalization, increased secondary clarification capacity and sludge handling modifications. Prior to these modifications plant performance was poor (BOD removal 83%, effluent BOD 66 mg/l).

Plant No. 274: A significant portion of flow treated by this plant is sanitary wastewater.

Plant No. 294: Plant performance (effluent TSS 95 mg/1) is poor considering the level of treatment technology employed (activated sludge followed by sand filtration).

APPENDIX E

CAPDET Methodology

APPENDIX E

METHODOLOGY

The basic calculation tool used to develop alternative engineering costs (with the exception of RBC costs) is the computer program, CAPDET (Computer Assisted Procedure For The Design and Evaluation of Wastewater Treatment Facilities).[E-1] The CAPDET computer model was developed jointly by the Corps of Engineers Waterway Experiment Station, Vicksburg, Mississipi and the EPA Office of Water and Waste Management.

The major purpose of the CAPDET model is to provide for the rapid design, cost estimating and ranking by cost of wastewater treatment plant alternatives. The model can be applied to industrial wastewater treatment system design, as well as Publicly Owned Treatment Works (POTWs), with modifications of selected computer program default values.

The CAPDET model provides flexibility and accuracy while maintaining ease of operation. The algorithm contains default values applicable to all wastewater parameters. These default values enable complete wastewater treatment design and costing by stipulating only average flow and a list of the treatment schemes to be considered. Any value in the CAPDET model (chemical data, cost data, unit operations parameters, etc.) can be varied, however, to reflect more current information, more localized cost data or specific waste treatment parameters applicable to industrial wastewater treatment.

The CAPDET model is not designed to select and sequence unit operations into a treatment system. The user must input a series of up to 20 "blocks" or waste treatment process functions into the model. Thus, the user inputs the basic treatment scheme to be costed into the model.

In each treatment block, up to ten different treatment alternatives can be considered. For example, a block containing complete mix activated sludge could also contain conventional activated sludge, extended aeration activated sludge, pure oxygen activated sludge and six other alternatives. The model will then design, estimate costs, and rank from cheapest to most expensive all possible combinations. Further, the model can also consider four separate treatment trains per run.

Another characteristic of the CAPDET model is its ability to consider up to three modifications of each treatment process. The model contains the process treatment parameters necessary to solve the unit process equations, namely chemical default data for certain wastewaters and such typical physical criteria as removal efficiency, overflow rate and average temperature. The CAPDET model allows the user direct access to any of these parameters. In fact, the user can run three different versions of any treatment process as alternatives in the same block or in different blocks. An example would be checking in one run the impact on effluent quality and plant costs of changing the overflow rate of a clarifier. CAPDET, then, is able to consider many different alternative treatment schemes, including multiple variants on one unit process.

After the treatment process alternatives to be considered have been selected and input into the model, each possible alternative treatment train is designed. The CAPDET model contains in its treatment catalog 64 large facility (>.5 MGD) and 23 small facility (<.5 MGD) unit processes, including sludge handling processes. Certain common industrial processes (API oil separation, steam stripping etc.) were not included in CAPDET because of CAPDET's original sanitary waste orientation. The writers of CAPDET, however, have included as part of the model a process known as the "dummy" process. To use this procedure, one calculates the percentage reduction for any parameters affected by the applicable unit process, plus any increase or decrease in effluent flow rate and sludges due to the process. These numbers are entered in the model and the dummy process is treated as if it were a process in the CAPDET treatment catalog. Like any other unit process, different modifications of the dummy processes can be considered as treatment alternatives. This flexibility enables the CAPDET model to simulate unit processes not in its treatment process file.

As the CAPDET model designs all possible alternative treatment systems, it determines the cost of each system. As with the design data, a complete set of default unit construction, operation and maintenance cost data are contained in the model. Thus, the cost of the treatment system can be calculated. For each treatment process, secondary design calculations are performed by the computer to determine the specific amounts of materials required: foundations, tanks, basins, walls and many other items which are individually designed by the model to arrive at values for such construction items as concrete, sand and gravel, size and length of pipe, chemical use, number of valves and pounds of steel plate. These items are then totaled for the specific treatment train being considered and the construction costs are computed. Equipment costs are calculated parametrically, with an attempt to optimize accuracy. The equipment cost data were provided by vendors of treatment equipment. The parameter was chosen which best represented the cost of that equipment as a straight line on a log-log plot (clarifier diameter being a more appropriate parameter than total clarifier flow rate for costing a clarifier mechanism). The total capital cost of the treatment system is, therefore, a hybrid of construction design calculations and parametric cost estimates.

Default values for all cost data are contained in the CAPDET model. As with all other data in the model, however, the user has the option of altering or updating the costs for nearly anything in the model. These changes can be made in the following ways:

1. Equipment and construction default data are based on first quarter 1977 costs. The model updates these cost data to the present.

2. Equipment costs, operating costs, operating manhours per year and construction material costs are all user selectable. Thus, if a user knows that standard blower costs are lower or highter than the default value in a particular area, then correct costs can be input. If parametric cost curves are to be updated, the user inputs the local cost for the standard sized unit (i.e., 90-foot clarifier mechanism) used in the model. The cost curve then will be adjusted

up or down, with the slope remaining unchanged. If local or current data are input, they will not be updated again by one of the cost indices.

3. Some costs are given as percentages of the total facility costs (e.g., administrative costs and inspection costs). These percentages can be changed depending on the judgment of the user or on local conditions.

4. Other costs are also accessible to the user. CAPDET calculates labor rates based on ratios with an Operator II rate. While these ratios are not user selectable, the default Operation II rate is alterable. Thus, the CAPDET model can account for variations in labor costs.

The CAPDET model also has some optional cost items which can be included as appropriate (i.e., special foundations, mobilization, site electrical costs, lab and administration buildings, etc.).

The CAPDET model compares treatment alternatives rather than adding unit operations until the effluent is below the desired efflent level. The model calculates the expected effluent from each alternative train and compares it with the desired effluent level. The model rejects those alternatives that do not meet the desired effluent quality and ranks (from the least expensive to the most expensive) the least expensive hundred alternatives that meet the criteria.

The general design bases for the CAPDET model were:

1. Costs expressed as first quarter 1979 dollars.

2. Capital costs representing total equipment costs (installed), contractor's overhead/profit, administration/legal expenses, architectural/engineering design fees, inspection fees, contingencies, technical costs and land costs.

3. Operating costs equal to the sum of costs for operating and maintenance labor, power, materials, chemicals, and administration and laboratory expenses.

4. Equivalent annual costs representing the amortization of the capital costs (capital recovery plus interest) at 10 percent and twenty years plus the annual operating costs.[E-2],[E-3]

5. Design constants based on a statistical analysis of the municipal wastewater treatment industry as well as on literature publications.[E-4]

6. Cost equations taken from correlations developed from data based on municipally owned treatment plants.[E-5]

Unit price input data and details of the direct nonconstruction costs are shown in Table E-1. Default waste characteristics present in the

TABLE E-1–COST INPUT PARAMETERS (10 PERCENT, 20 YEARS)

COST INDEXES	UNIT PRICES
Building	48.00 $/sq ft
Excavation	1.20 $/cu yd
Wall concrete (reinforced, in-place)	207.00 $/cu yd
Slab concrete (reinforced, in-place)	91.00 $/cu yd
Marshall and Swift Index (equipment cost)	577.00
Crane rental	67.00 $/hr
EPA Construction Cost Index	132.00
Canopy roof	15.75 $/sq ft
Labor rate (equipment installation)	13.40 $/hr
Operator Class II	7.50 $/hr
Electricity	0.04 $/kw hr
Chemical Cost	
Lime	0.03 $/lb
Alum	0.04 $/lb
Iron salts	0.06 $/lb
Polymer	1.62 $/lb
Engineering News Record Cost Index	2886.00
Handrail, (in-place)	25.20 $/ft
Pipe Cost Index	295.20
Pipe installation labor rate	14.70 $/hr
Eight-inch pipe	9.08 $/ft
Eight-inch pipe bend	86.82 $/unit
Eight-inch pipe tee	128.49 $/unit
Eight-inch pipe valve	1346.16 $/unit

INDIRECT NON-CONSTRUCTION COSTS	(AS % OF CONSTRUCTION COST)
Miscellaneous non-construction cost	5.0%
Admin/legal	2.0%
Inspection	2.0%
Contingencies	11.5%
Profit and overhead (contractor's)	22.0%
Technical cost	2.0%

CAPDET model are summarized in Table E-2. Table E-3 lists removal efficiencies of pollutants built into the program.

An evaluation of CAPDET suggests the following limitations:

1. CAPDET was originally designed for municipal wastewater plants and therefore requires certain adjustments for industrial applications. The characteristics of municipal raw wastewaters are normally more consistent among different locations than those of industrial wastewater, and the parameters relating to the treatability are more applicable among the different locations than are the treatment parameters of industrial wastewaters.

   This permits the use of CAPDET for the POTW cost estimating without changes in the default values. The use of CAPDET for evaluations based on industrial wastewaters requires changes in the default values, particularly in the reaction rate constant, influent BOD concentrations, influent TSS, nutrient balances and other factors which differentiate the composition of industrial wastewaters from municipal wastewaters.

2. The costs generated by CAPDET reflected grass roots installations. This version of CAPDET is not capable of directly generating upgrade costs for modifications or replacements of existing equipment. Many OCPS plants may require only minor adjustments to current facilities or management practices to reach proposed effluent targets. Although these engineering options may be available to specific plants to achieve the target effluent concentrations, CAPDET, as used in this study, is limited to estimating the designs and costs for entire wastewater treatment unit process additions (second stage treatment).

3. Land requirements and administrative and laboratory costs calculated by CAPDET are related to plant capacity rather than to discrete unit operations. The relationship of costs to flow rate limits CAPDET in the estimation of discrete (singular) units as opposed to entire plant facilities. As a result, CAPDET predicts similar land costs for clarification and an entire activated sludge unit for the same flow rate. As a percentage of the total costs, land, administrative and laboratory costs represent a small portion of an entire facility estimate. For a single unit, these costs have a much greater effect.

TABLE E-2

CAPDET DEFAULT INFLUENT WASTE CHARACTERISTICS

TEMPERATURE	18 °C	
SUSPENDED SOLIDS	200	MG/L
VOLATILE SOLIDS	60	% OF SS
SETTLEABLE SOLIDS	15	MG/L
BOD_5	250	MG/L
SBOD	75	MG/L
COD	500	MG/L
SCOD	400	MG/L
pH	7.6	
CATIONS	160	MG/L
ANIONS	160	MG/L
PO_4	18	MG/L
TKN	45	MG/L
NH_3	25	MG/L
NO_2	0	MG/L
NO_3	0	MG/L
OIL AND GREASE	80	MG/L

TABLE E-3

WASTE CHARACTERISTIC REMOVAL DEFAULT
VALUES FOR CAPDET PROCESSES

	WASTE CHARACTERISTIC REMOVALS FOR							
PROCESS	BOD_5	TSS	COD	OIL & GREASE	TKN	PHOS	NH_3	Settle SOLID
Dissolved Air Flotation	30%	80%	30%	-	10%	-	-	-
Clarification	32%	58%	40%	-	5%	5%	-	-
Activated Sludge	USER INPUT INFLUENT AND EFFLUENT	USER INPUT TO SECODARY CLARIFIER	1.5 x BOD_{EFF}	0	30%	30%	SET EQUAL TO TKN	0
Aerated Lagoon	USER INPUT INFLUENT AND EFFLUENT	USER INPUT TO SECONDARY CLARIFIER	ASSUME		SAME AS ASL			
Multimedia Filtration	SET EFFLUENT EQUAL TO $BOD_{SOLUBLE}$ INFLUENT	60%	SET EFFLUENT EQUAL TO $COD_{SOLUBLE}$ INFLUENT	0	PASS ON THROUGH	PASS ON THROUGH	PASS THROUGH	0

APPENDIX F - DISCRETE UNIT COST CURVES

1 GENERAL

This appendix supplements the engineering cost section of this report (Section 8) with a detailed presentation of the discrete unit cost curves discussed in Paragraph 8.2.3.

The curves presented contain costs for the treatment technology alternatives considered in the plant-by-plant analysis for various influent and effluent concentrations (mg/l) and flow rates (MGD). The terms frequently listed on the curves are defined as follows:

(1) Capital Costs are the costs representing the total installed equipment costs, contractor's overhead/profit, administration/legal expenses, A/E design fees, inspection fees, contingencies, technical costs, and land costs.

(2) Operating Costs are the costs equal to the sum of costs for operating and maintenance labor, power, materials, chemicals, and administration and laboratory expenses.

(3) Equivalent Annual Costs (Annual Costs) are those costs representing the amortization of the capital costs (capital recovery plus interest) at 10 percent and twenty years, plus the annual operating costs.

(4) M$, M$/yr are costs expressed as first quarter 1979 million dollars (per year for operating and equivalent annual costs).

The procedure for obtaining the costs used for the plant-by-plant analysis, is as follows:

(1) Locate the set of curves for the technology being considered.

(2) Look for the influent concentration (reported effluent) for BOD in the upper right hand corner of the page among the various graphs. Note that solids removal technologies are directly related to flow and that concentration levels are only limiting conditions of the treatment alternative. The influent concentrations are not listed on the graphs for solids removals alternatives.

(3) Select the capital cost (left axis) corresponding to the flow (bottom axis) and effluent concentration (curve) from the capital, operating, and annual cost pages. One cost should be obtained from each page for a given flow, influent BOD and effluent BOD. The costs for solid removal are flow related and all three costs can be obtained from one page for each technology alternative.

(4) Repeat this procedure for each target and continue for any plant being considered.

(5) For influent concentrations, assume a 15 percent accuracy range. Occasionally interpretation between two sets of costs may be required. This estimation technique is within the accuracy of the costs.

The cost curves are presented for a variety of effluent BOD concentrations for each biological alternative. Given a relative accuracy of 15 percent for the BOD reported value, the cost curves are basically equivalent for BOD targets with the same range. For example, the costs for a target of 50 mg/l BOD are approximately equivalent for targets ranging from 40 to 60 mg/l. The range for 30 mg/l is 25 to 35 mg/l. For estimating purposes, the curves for 10 mg/l represent the 20 mg/l target. In many cases, there is a lack of sensitivity in the costs for changes in effluent targets at lower influent concentrations and flows. A discussions of the sensitivities of the costs are provided in Section 8. The design bases and cost model limitations are also discussed in Section 8.

From the information and bases presented in this appendix, additional analysis of the plants may be pursued.

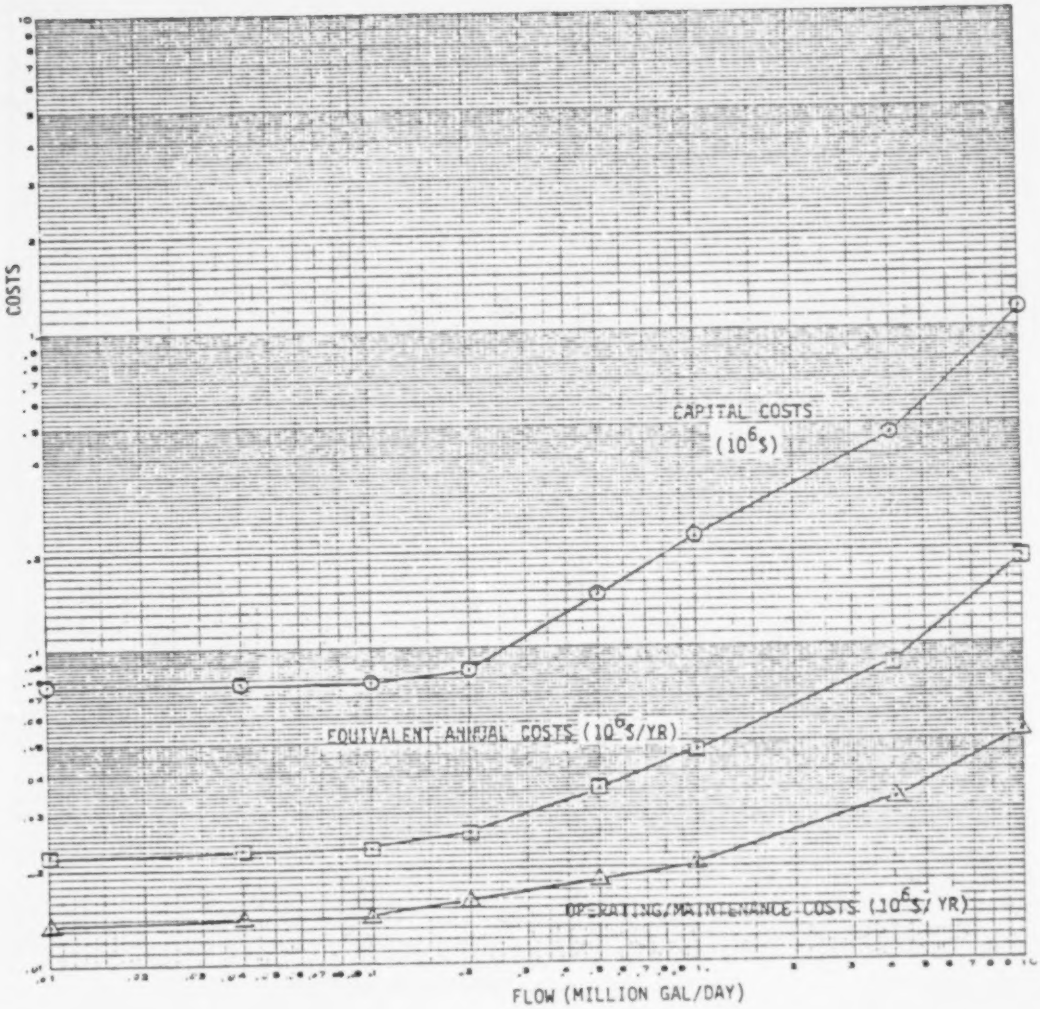


FIGURE 1—DISSOLVED AIR FLOTATION ANNUAL, CAPITAL AND OPERATING COSTS

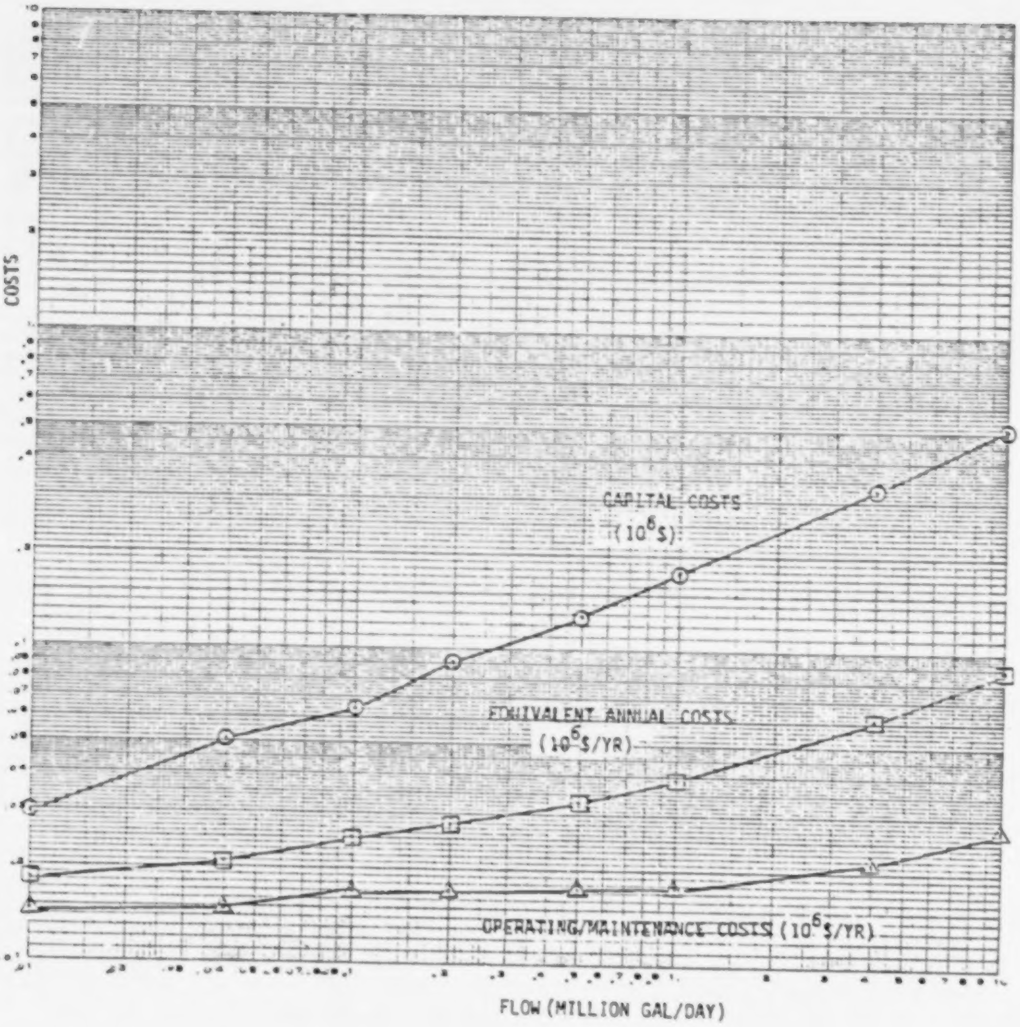
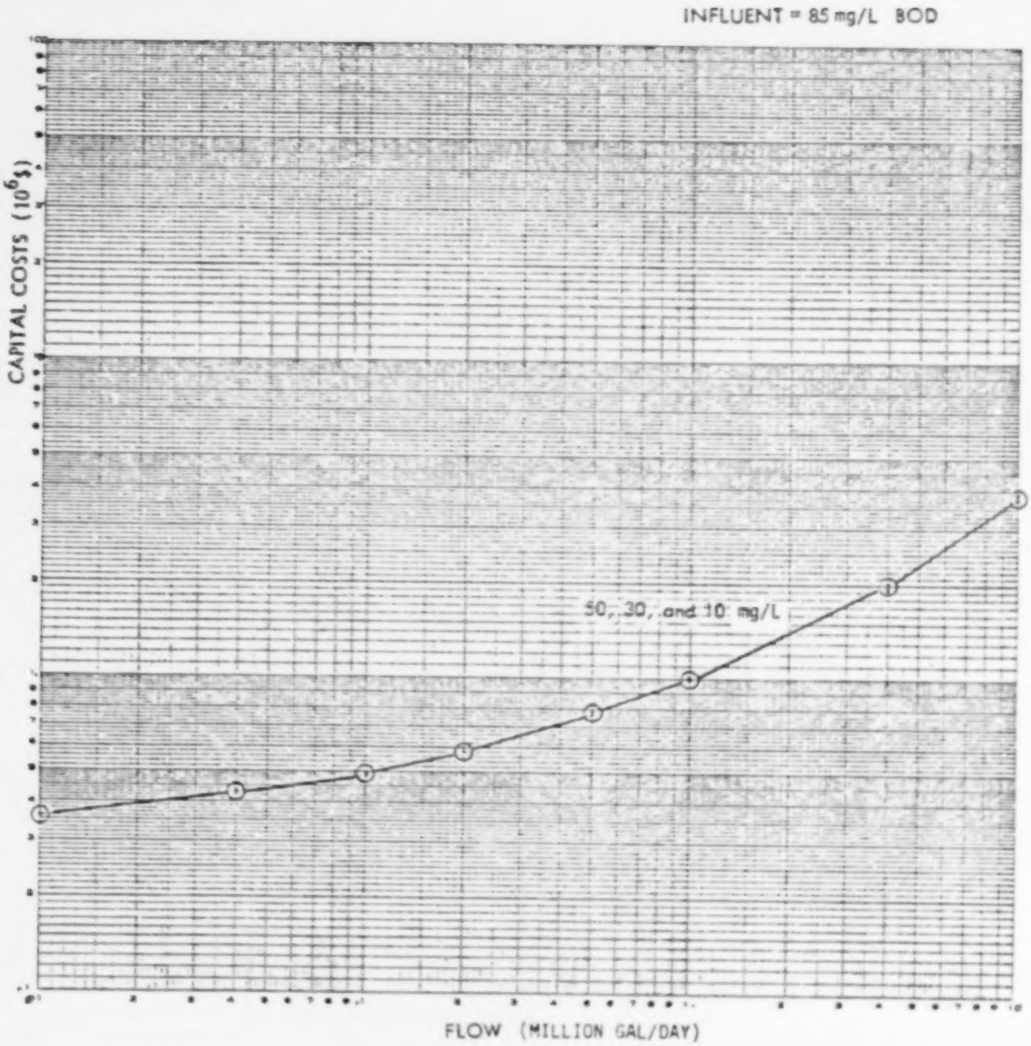


FIGURE 2—SEDIMENTATION ANNUAL, CAPITAL AND OPERATING COSTS



FIGURES 3—ACTIVATED SLUDGE ANNUAL (85mg/l)

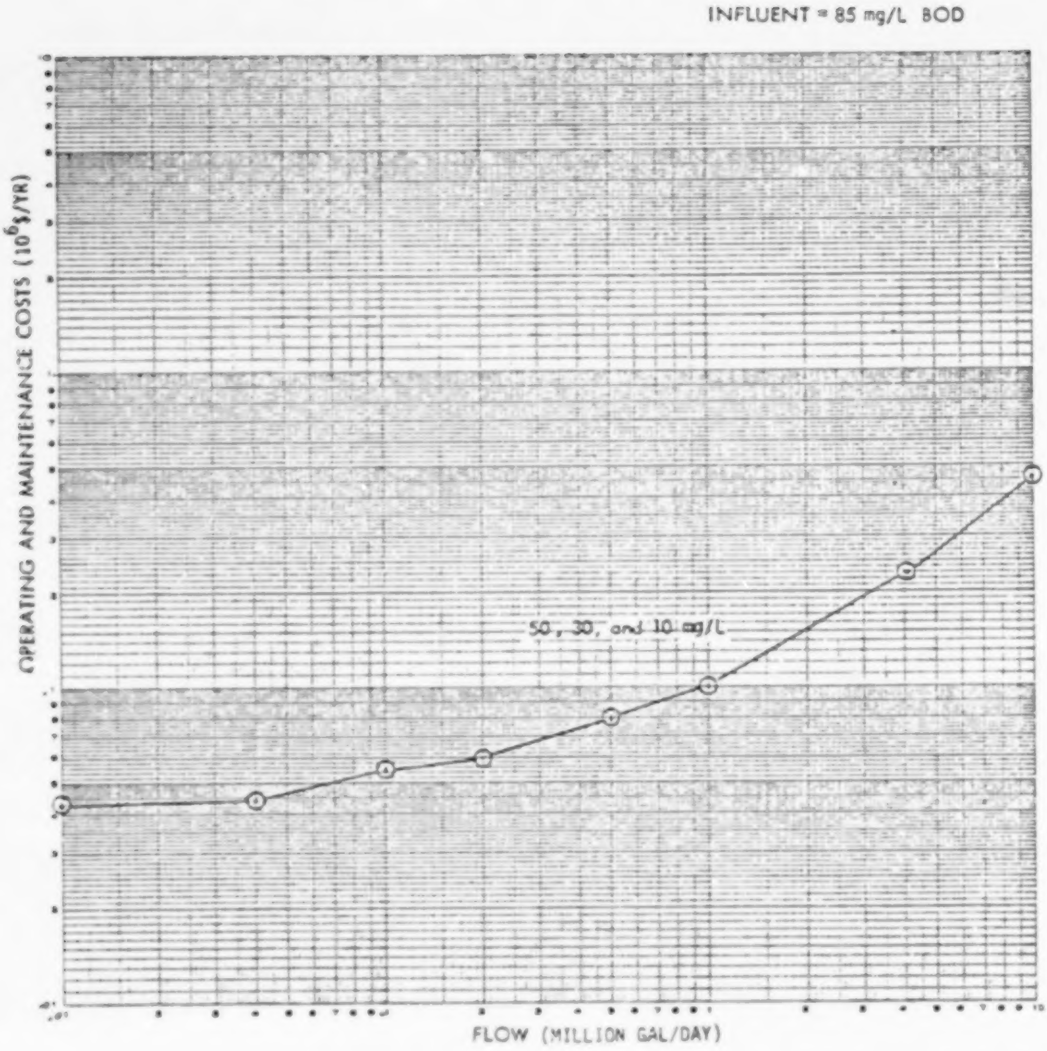


FIGURE 4—ACTIVATED SLUDGE CAPITAL COSTS (85 mg/l)

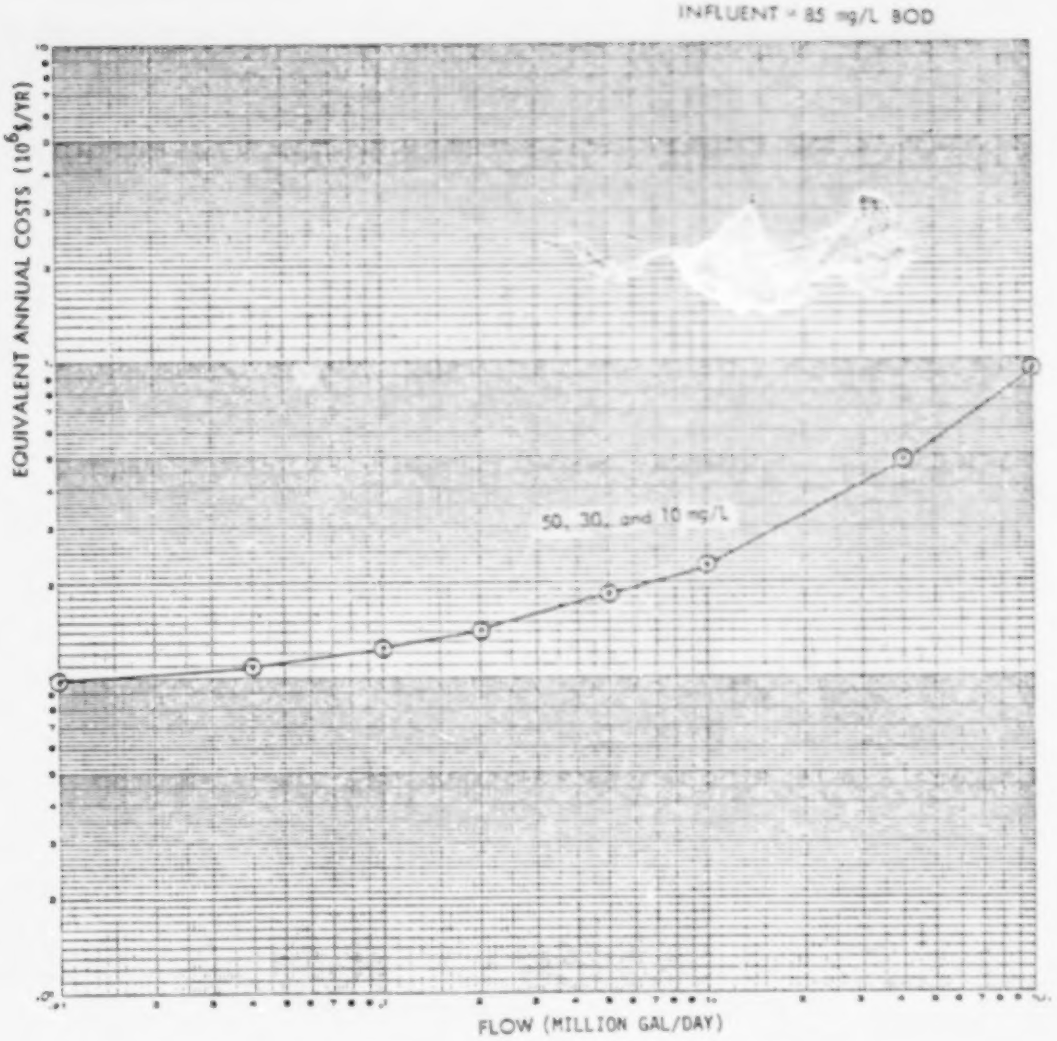


FIGURE 5—ACTIVATED SLUDGE OPERATING COSTS (85 mg/l)

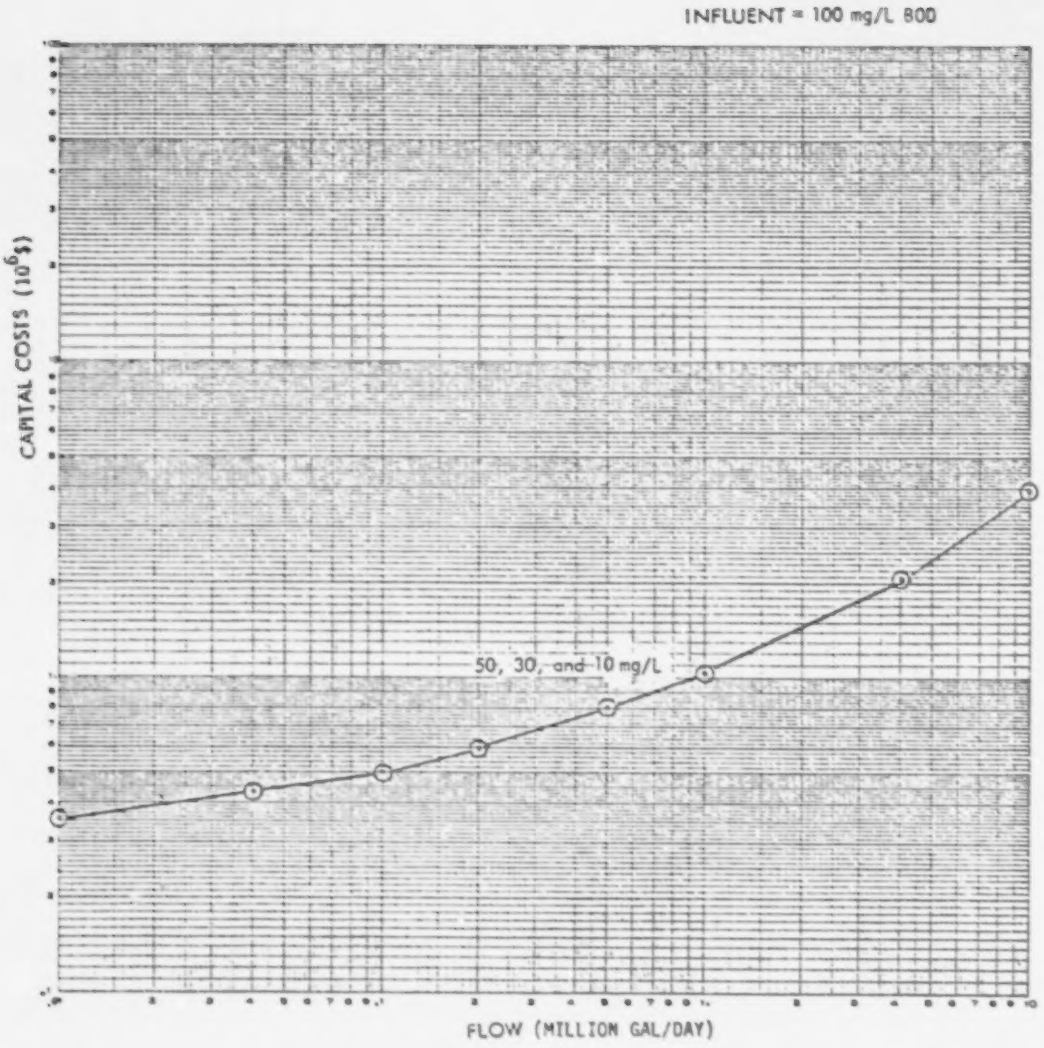


FIGURE 6—ACTIVATED SLUDGE ANNUAL COSTS (100 mg/l)

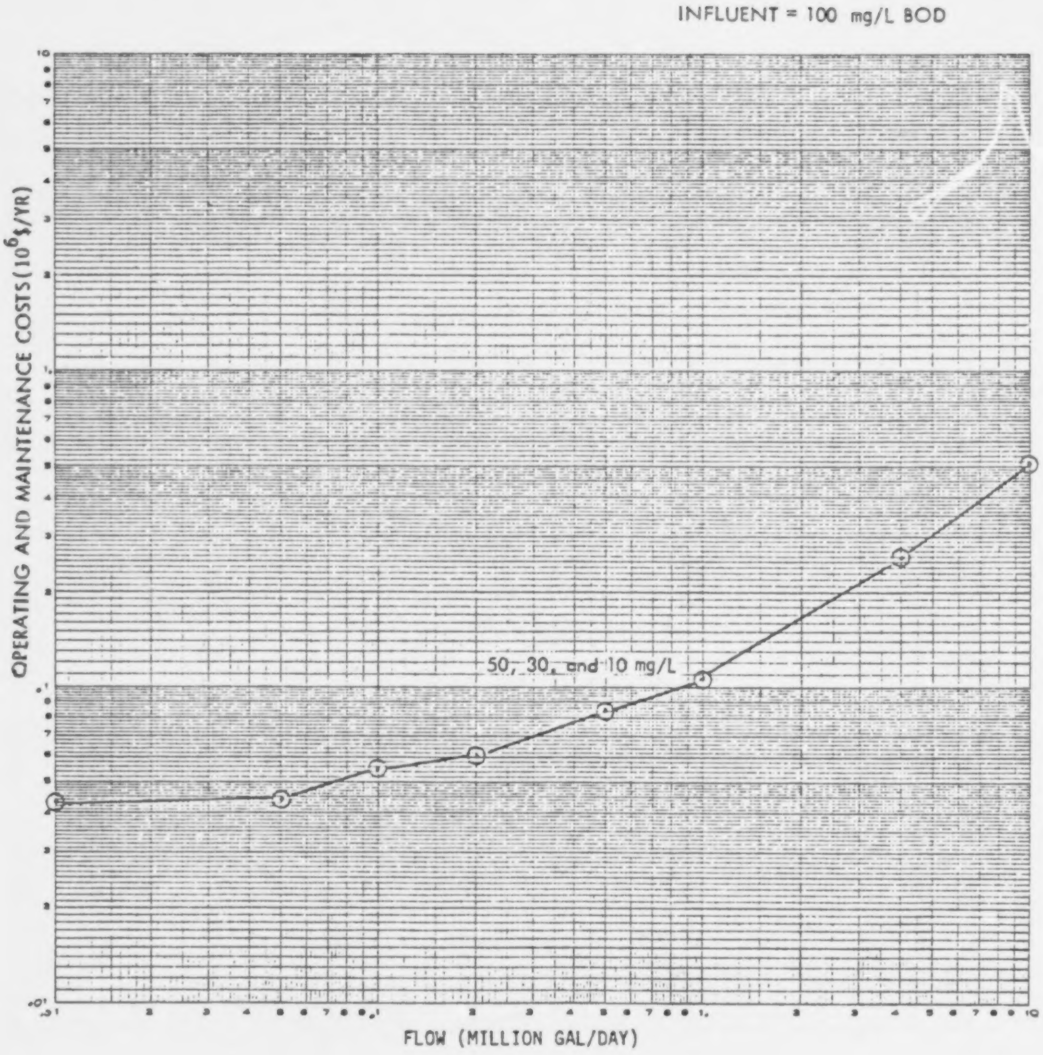


FIGURE 7—ACTIVATED SLUDGE CAPITAL COSTS (100 mg/l)

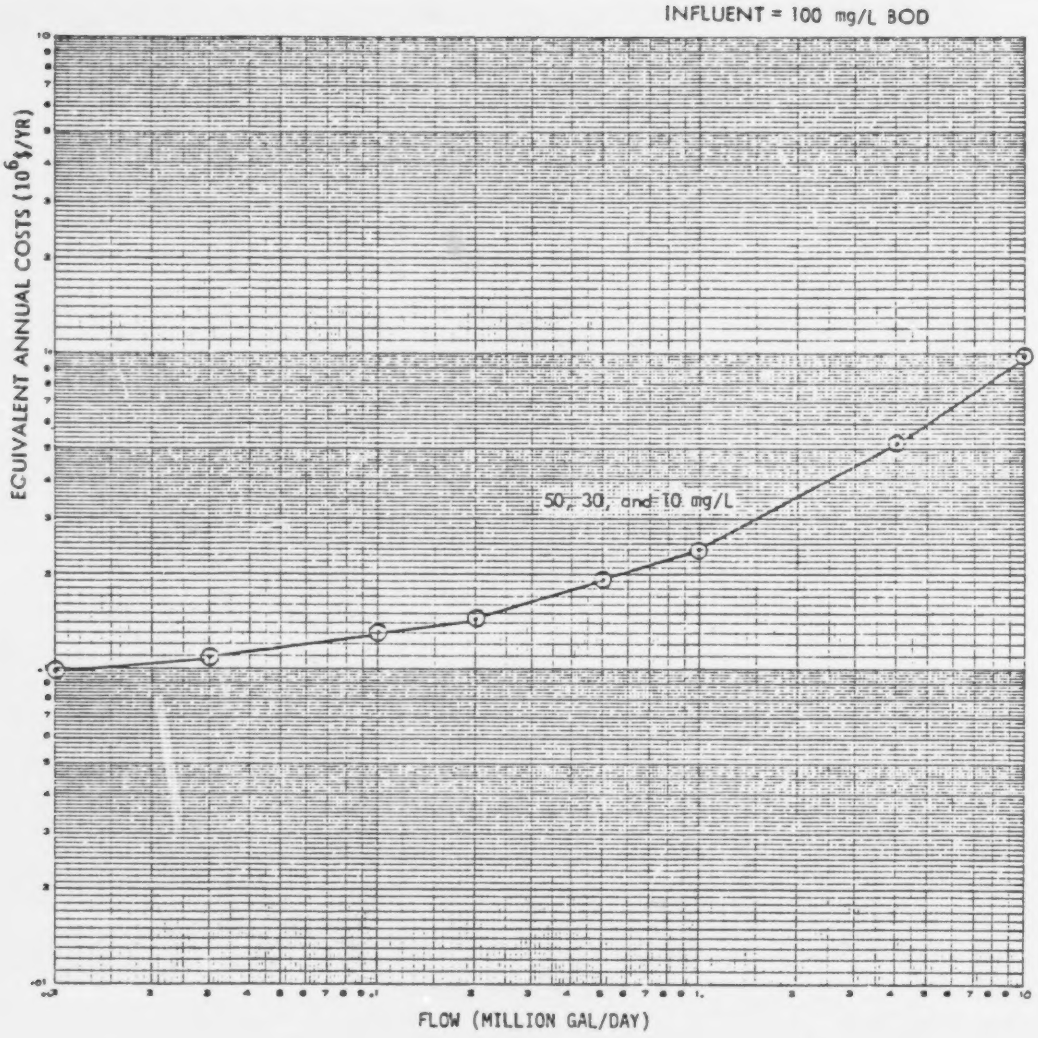


FIGURE 8—ACTIVATED SLUDGE OPERATING COSTS (100 mg/l)

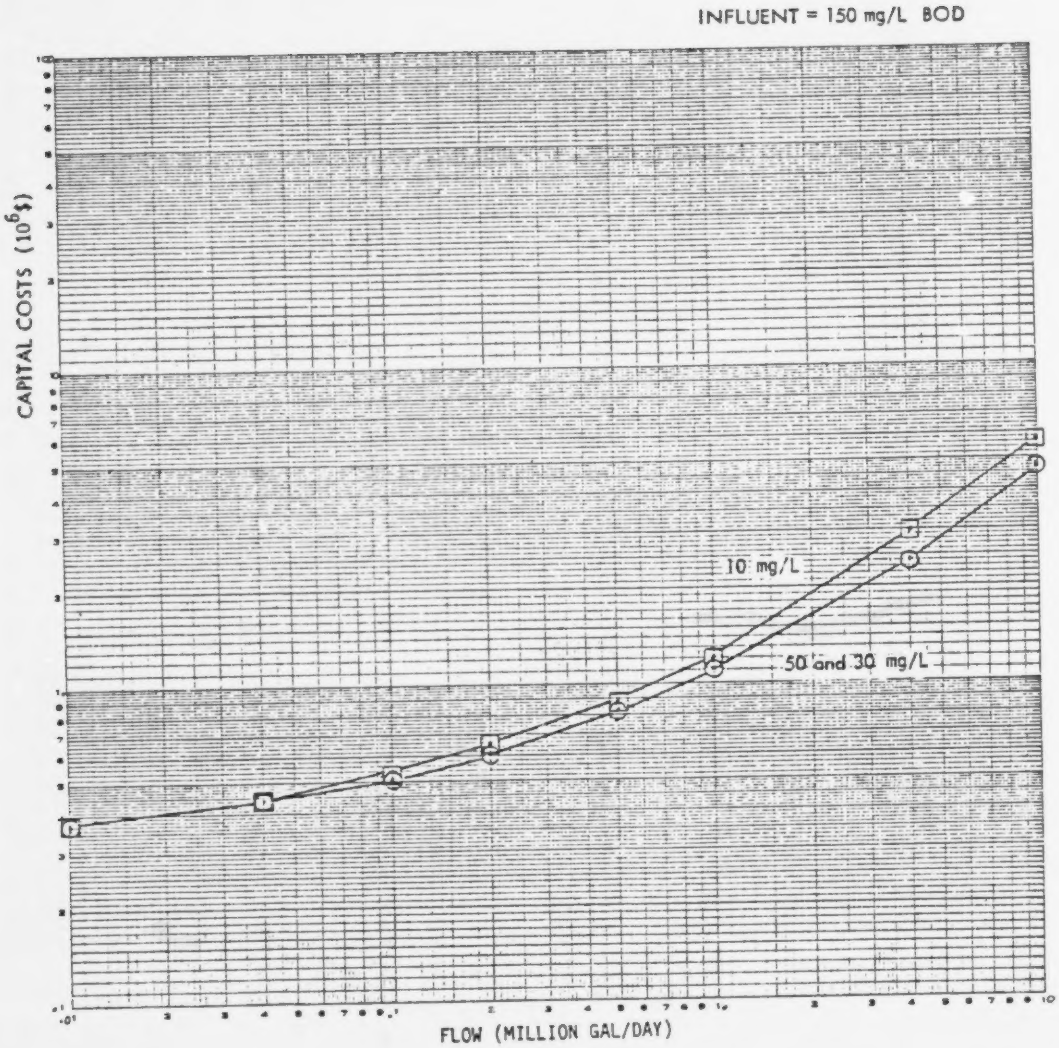


FIGURE 9—ACTIVATED SLUDGE ANNUAL COSTS (150 mg/l)

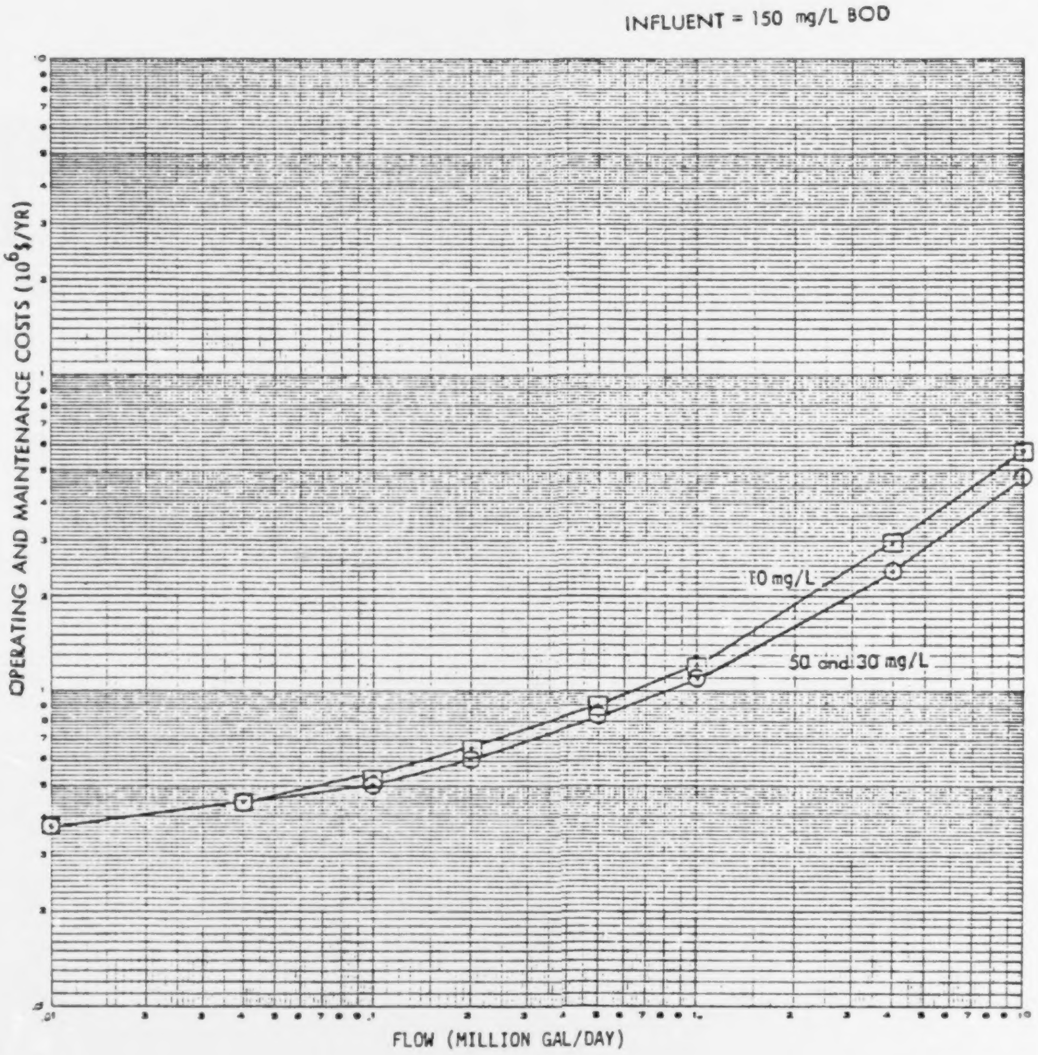


FIGURE 10—ACTIVATED SLUDGE CAPITAL COSTS (150 mg/l)

INFLUENT = 150 mg/L BOD

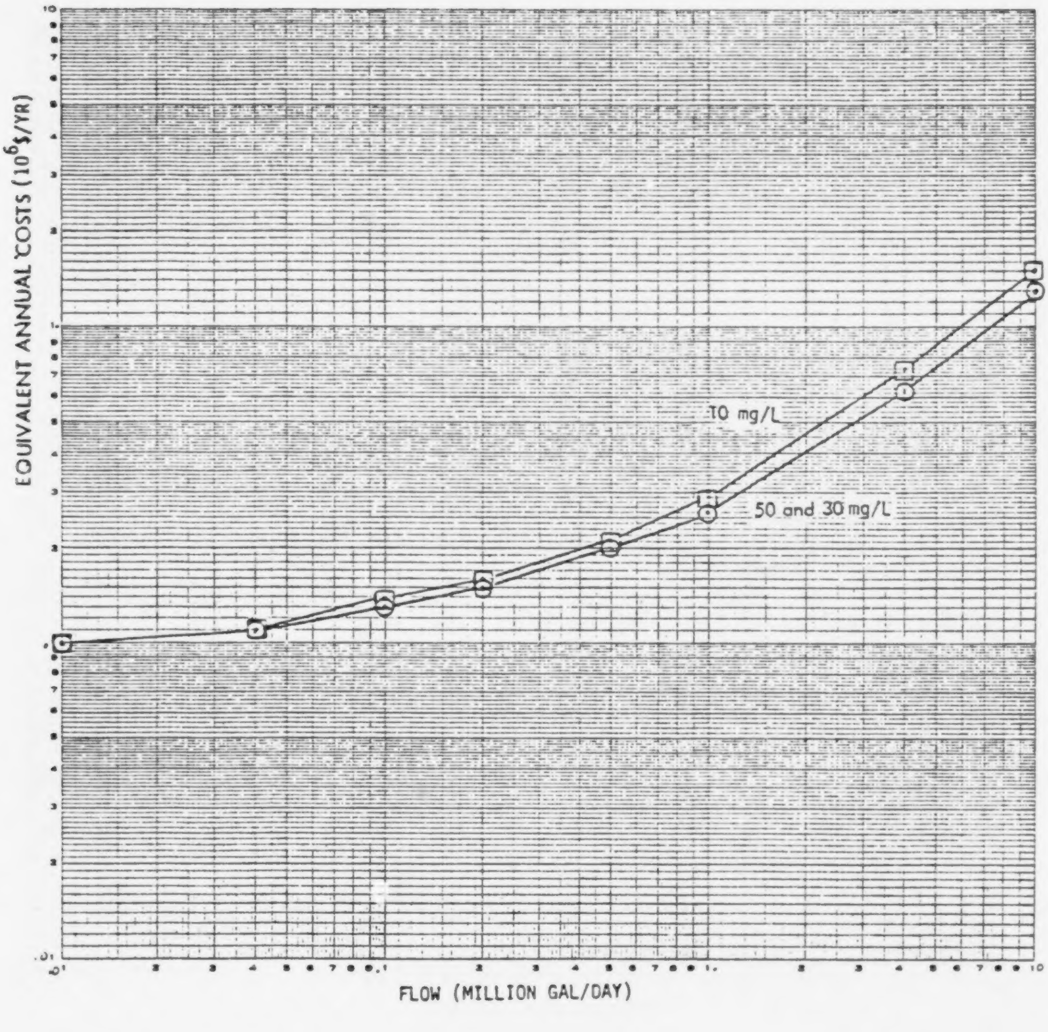


FIGURE 11—ACTIVATED SLUDGE OPERATING COSTS (150 mg/l)

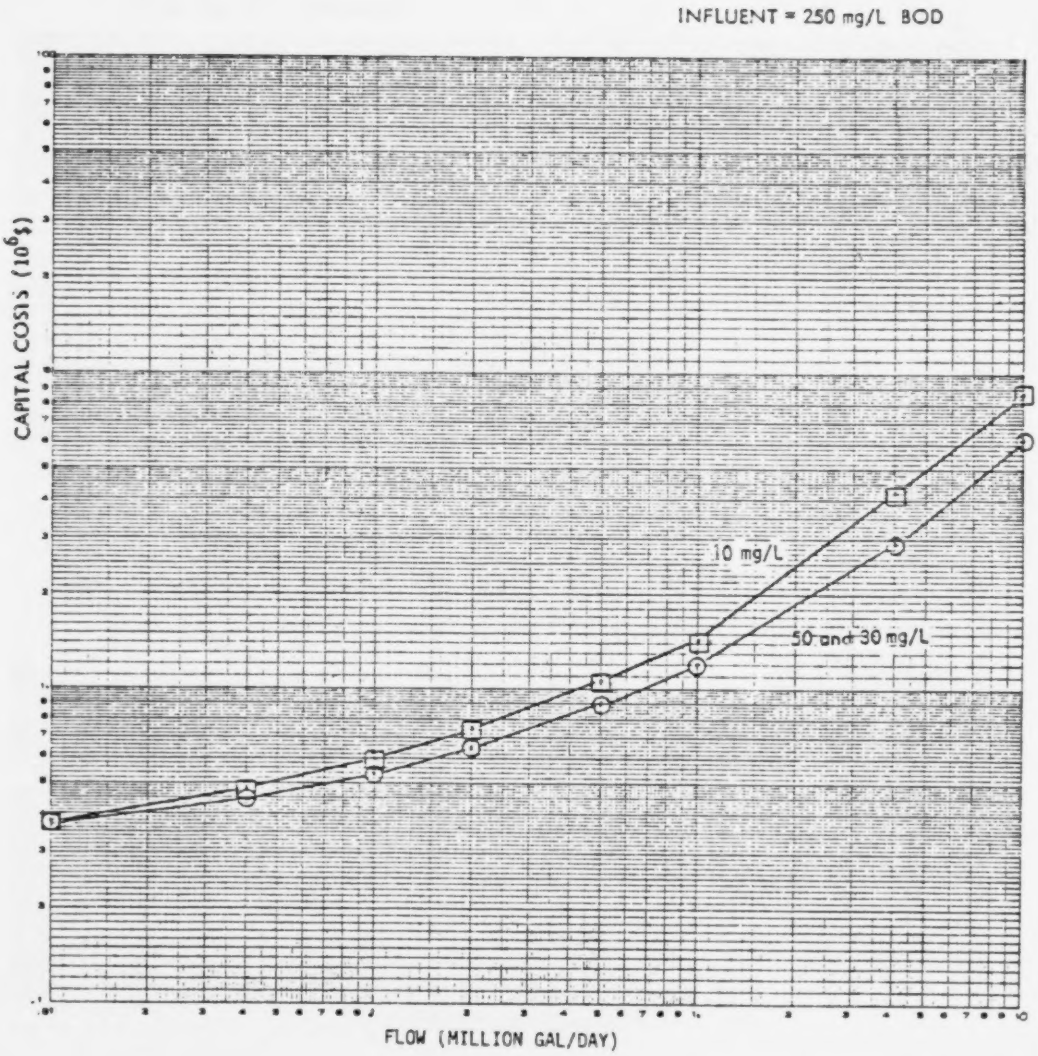


FIGURE 12—ACTIVATED SLUDGE ANNUAL COSTS (250 mg/l)

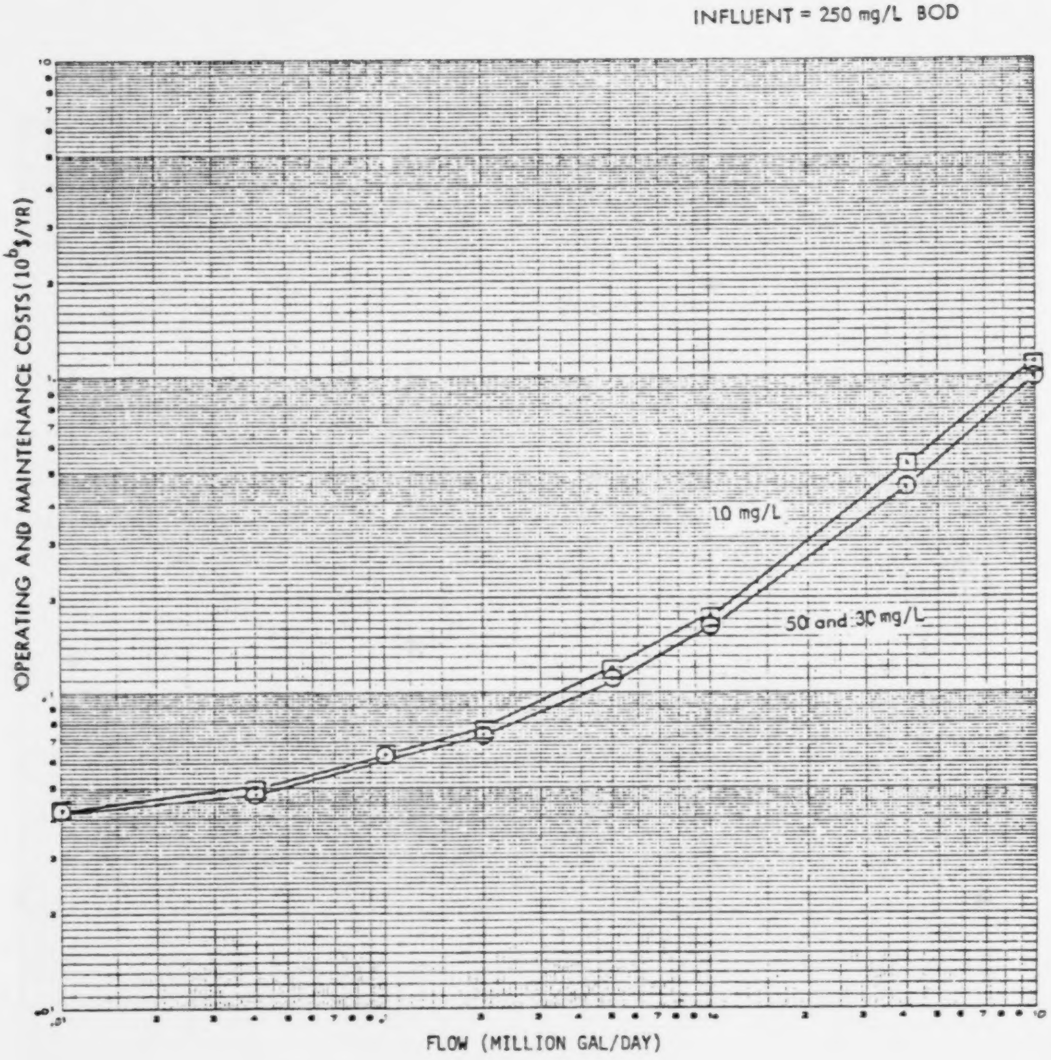


FIGURE 13—ACTIVATED SLUDGE CAPITAL COSTS (250 mg/l)

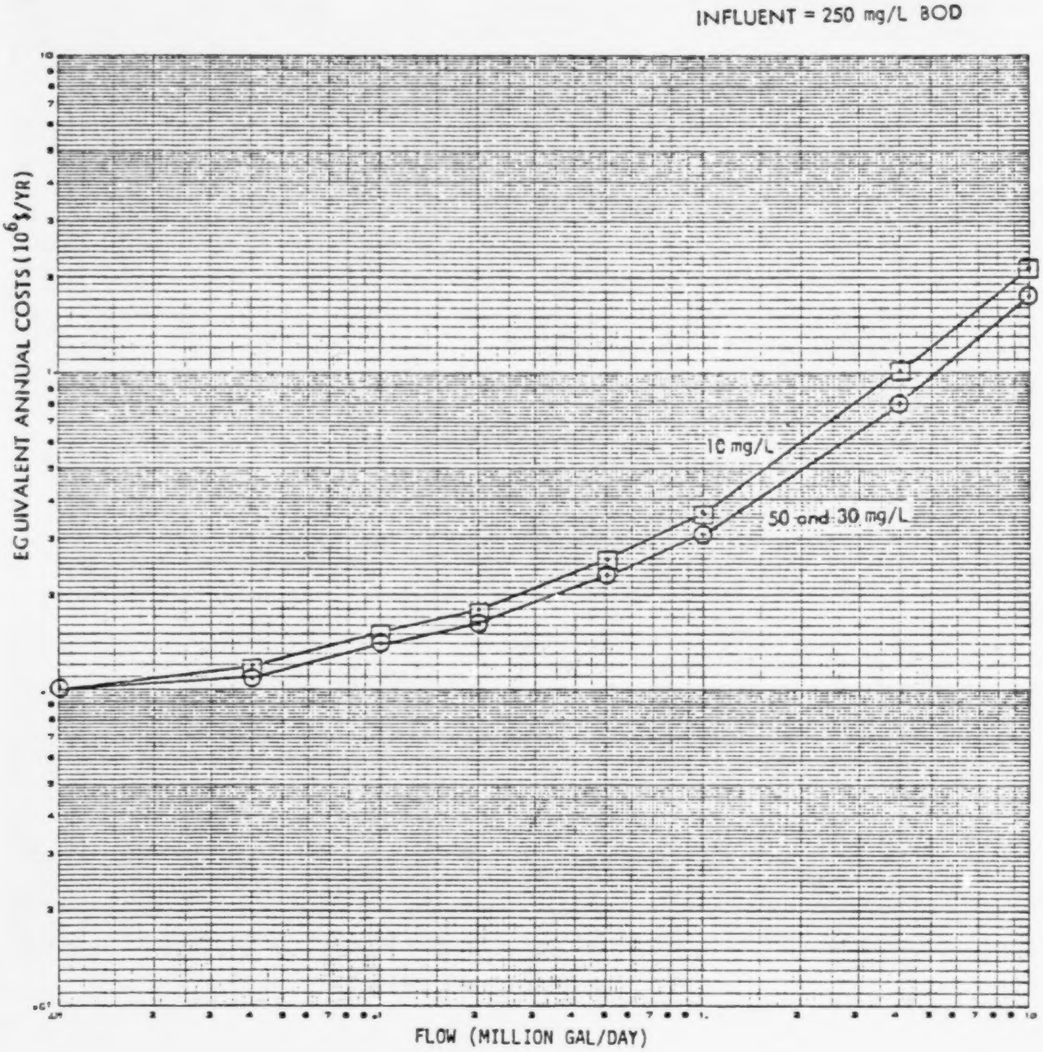


FIGURE 14—ACTIVATED SLUDGE OPERATING COSTS (250 mg/l)

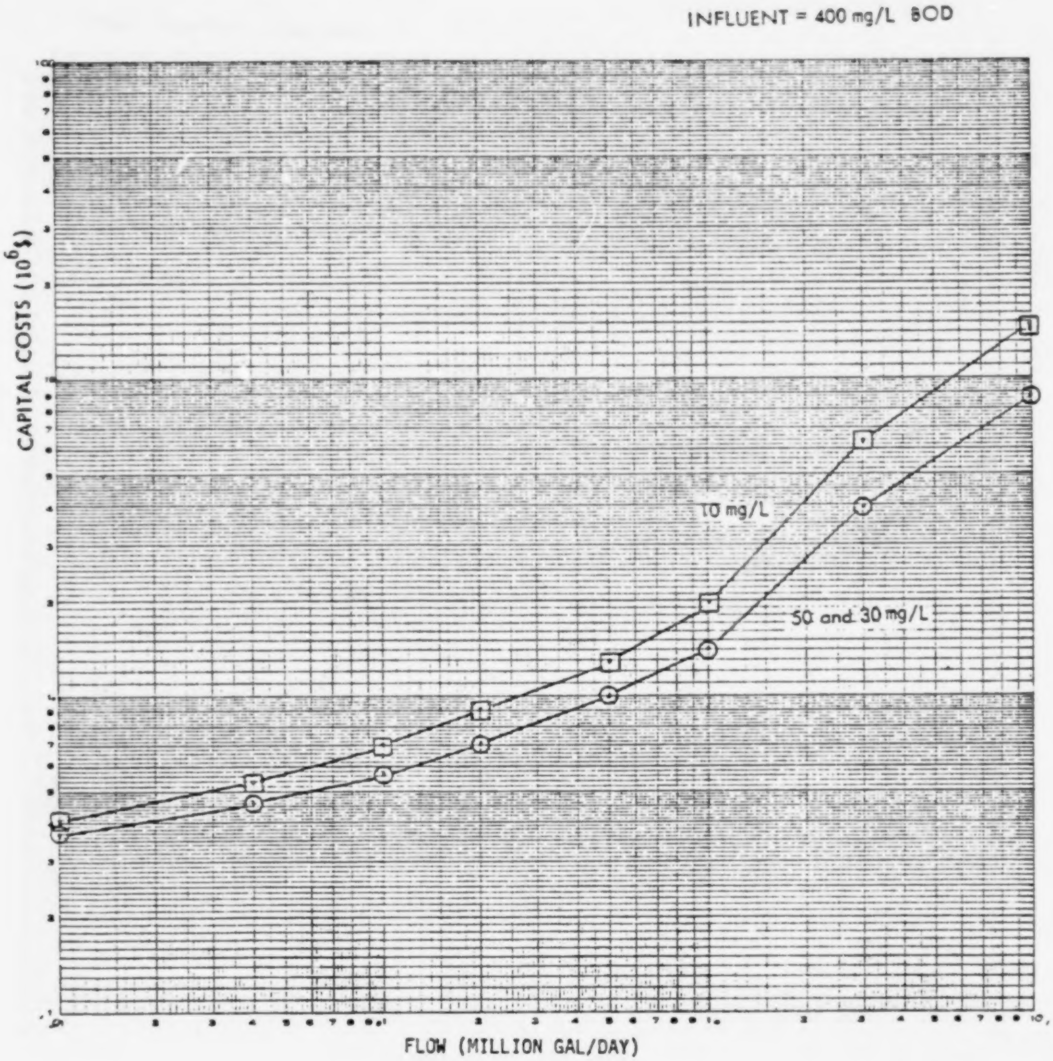


FIGURE 15

ACTIVATED SLUDGE ANNUAL COSTS (400 mg/l)

INFLUENT = 400 mg/L BOD

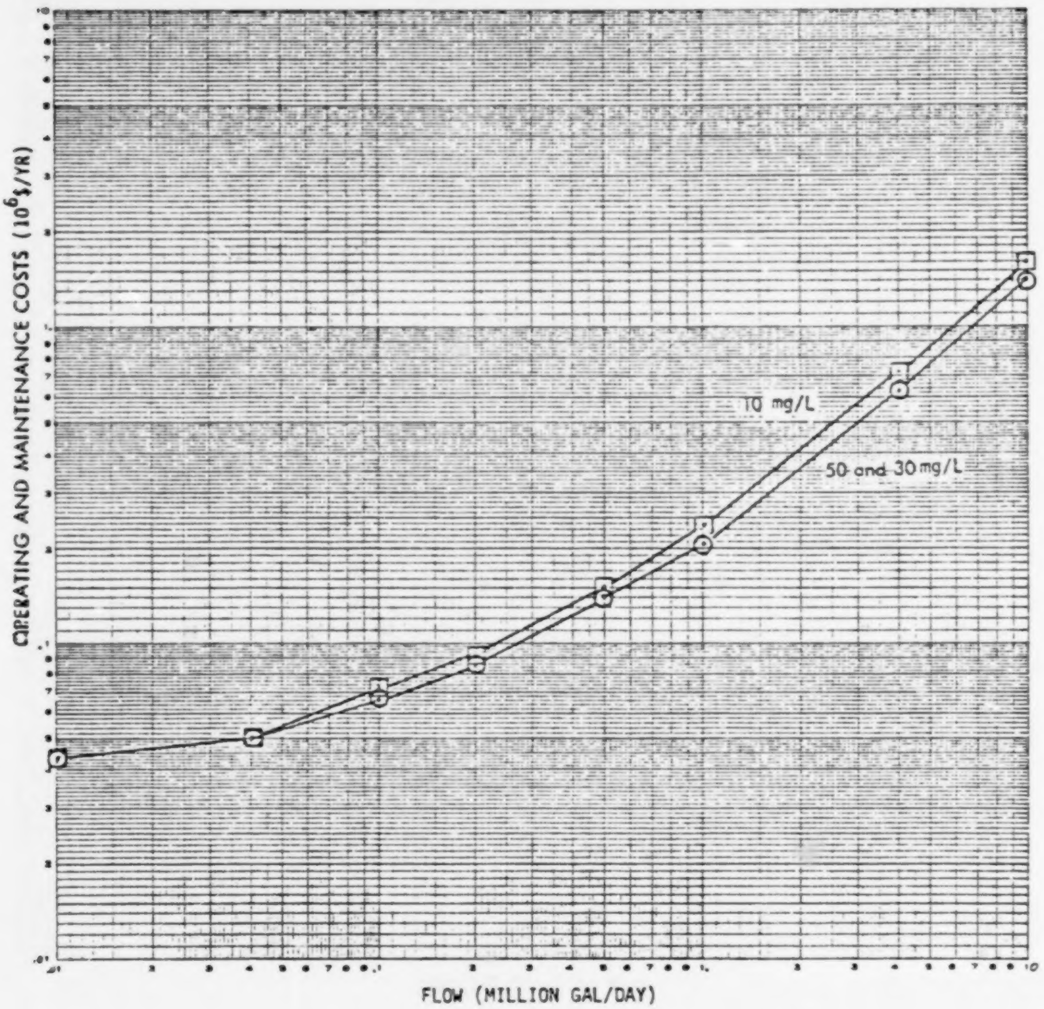


FIGURE 16—ACTIVATED SLUDGE CAPITAL COSTS (400 mg/l)

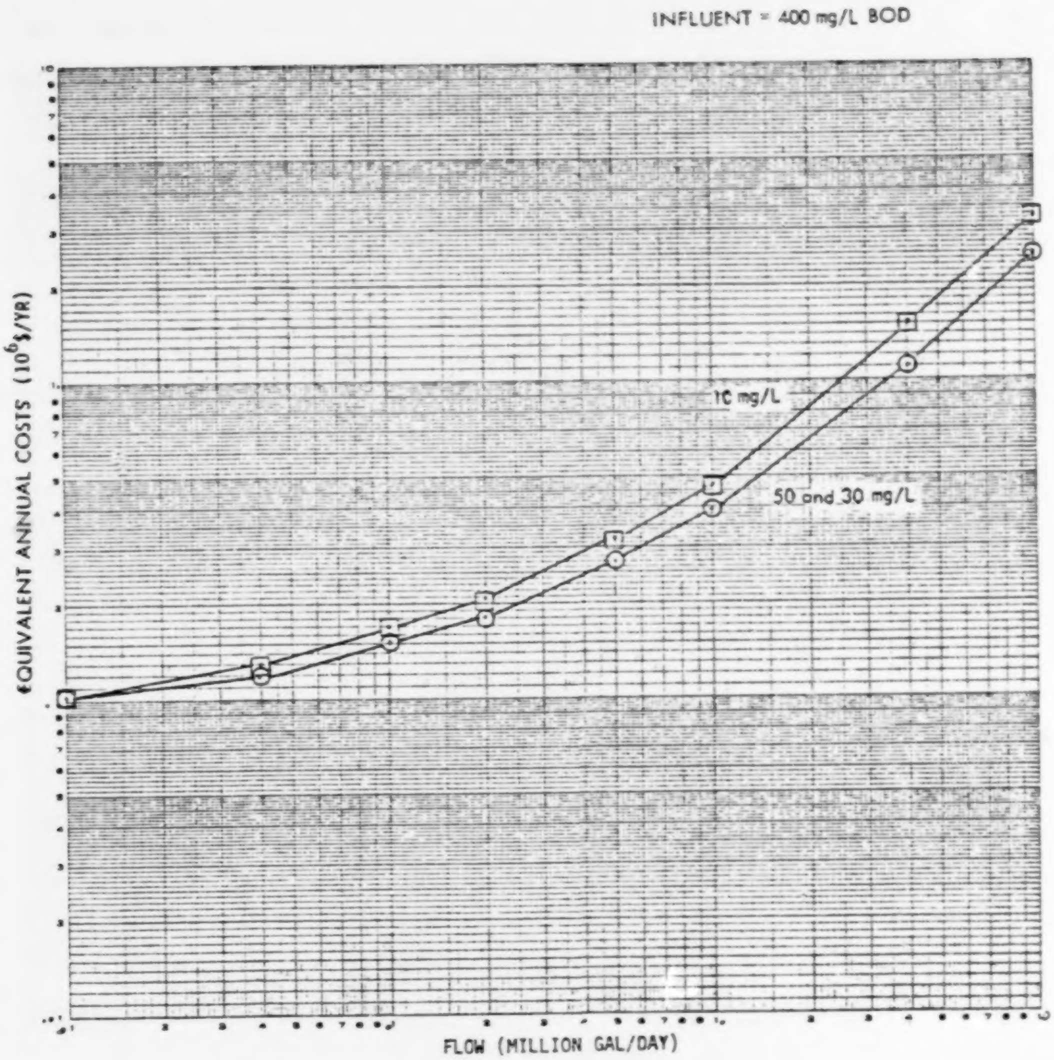


FIGURE 17—ACTIVATED SLUDGE OPERATING COSTS (400 mg/l)

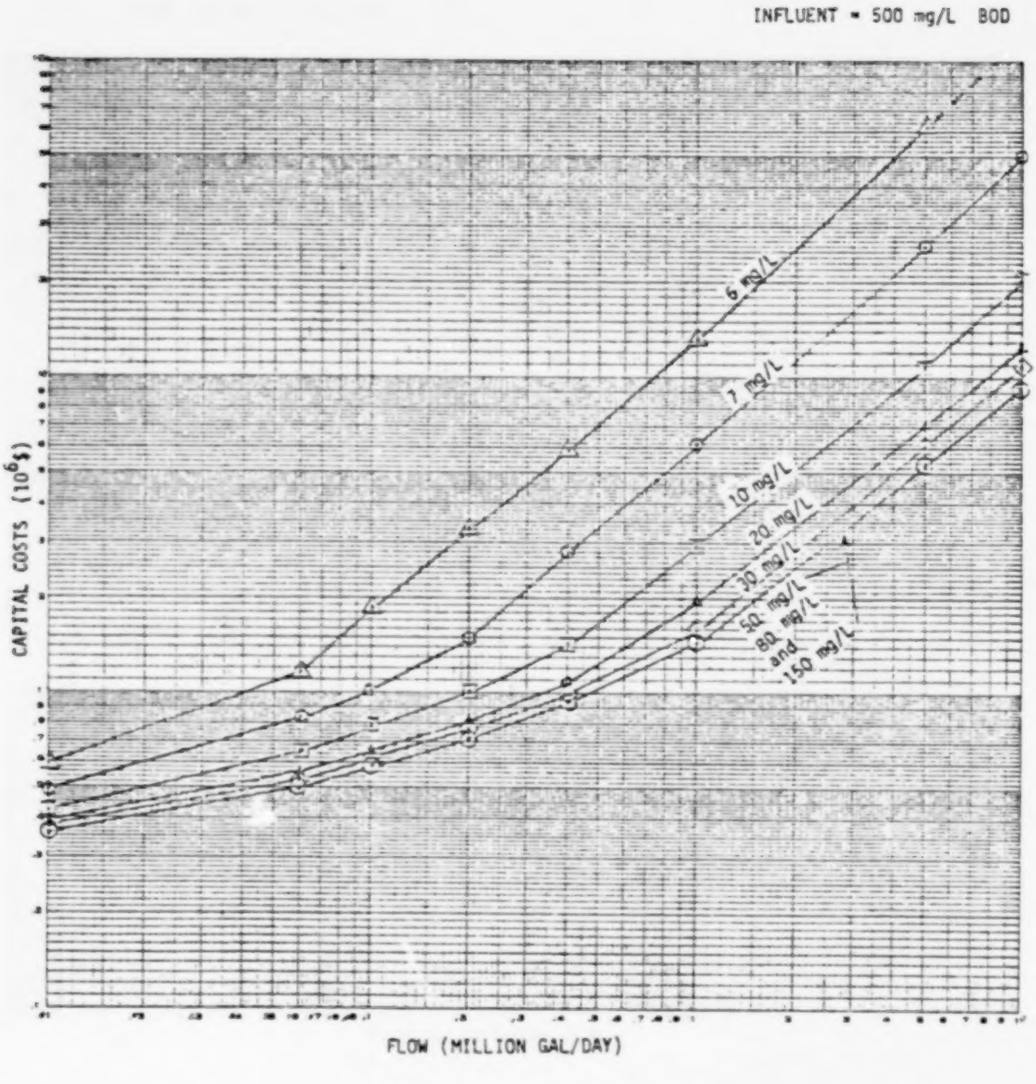


FIGURE 18—ACTIVATED SLUDGE ANNUAL COSTS (500 mg/l)

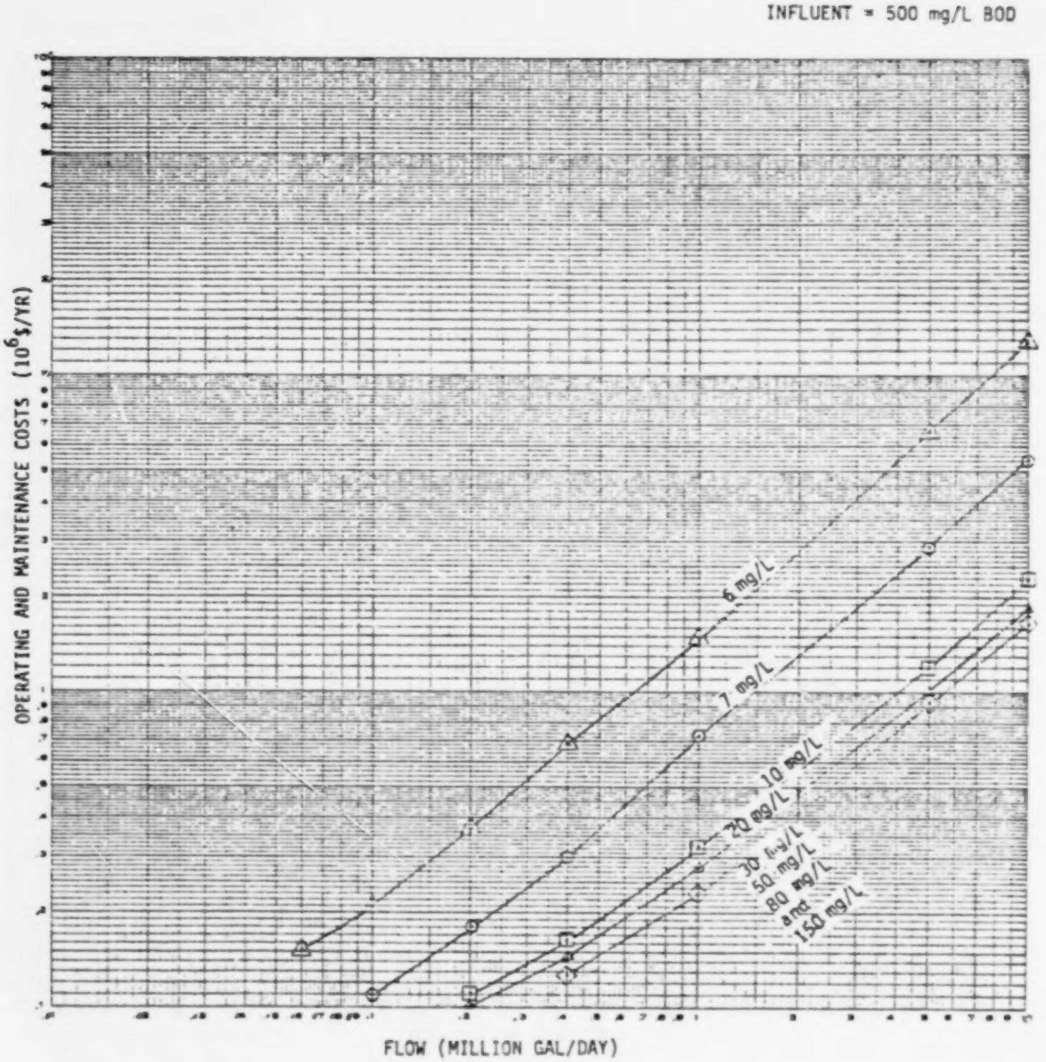


FIGURE 19—ACTIVATED SLUDGE CAPITAL COSTS (500 mg/l)

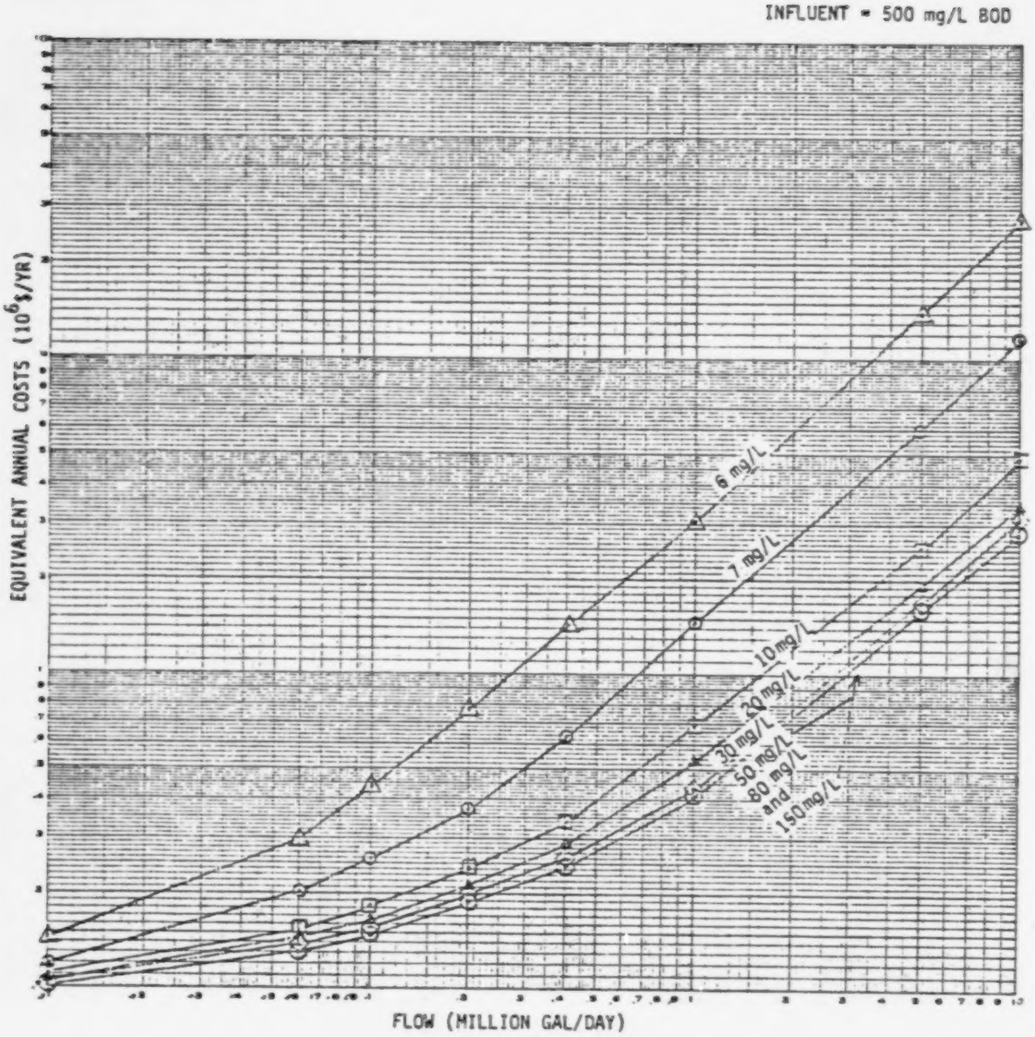


FIGURE 20—ACTIVATED SLUDGE OPERATING COSTS (500 mg/l)

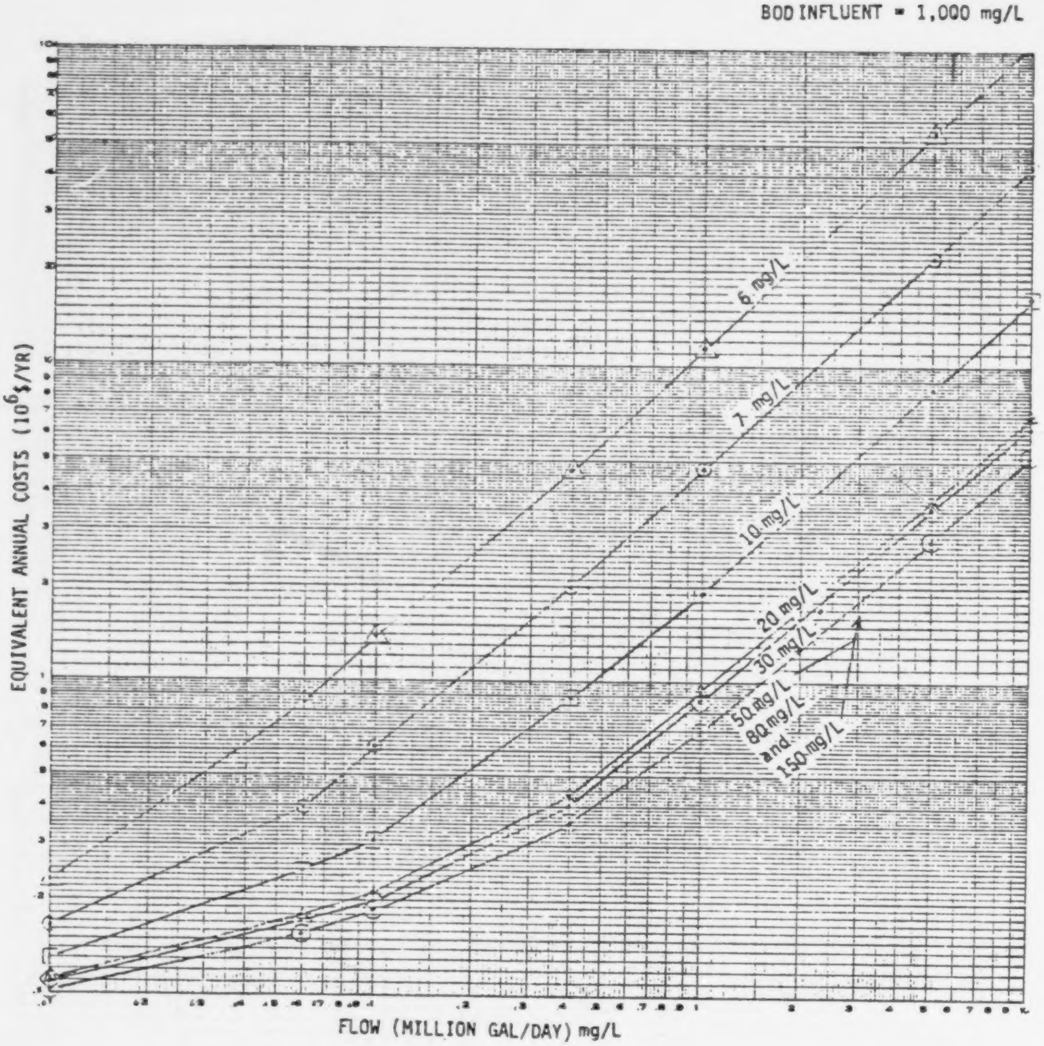


FIGURE 21—ACTIVATED SLUDGE ANNUAL COSTS (1000 mg/l)

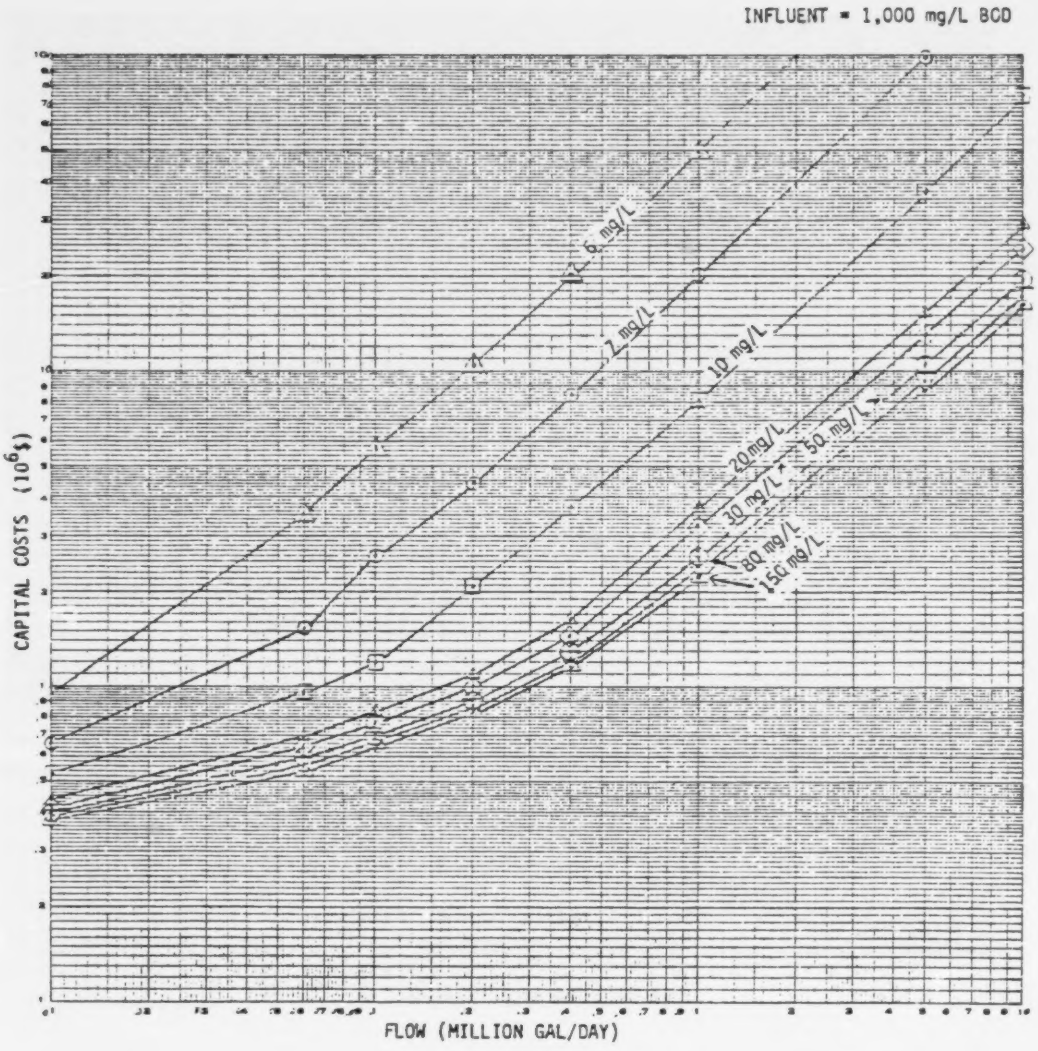


FIGURE 22—ACTIVATED SLUDGE CAPITAL COSTS (1000 mg/l)

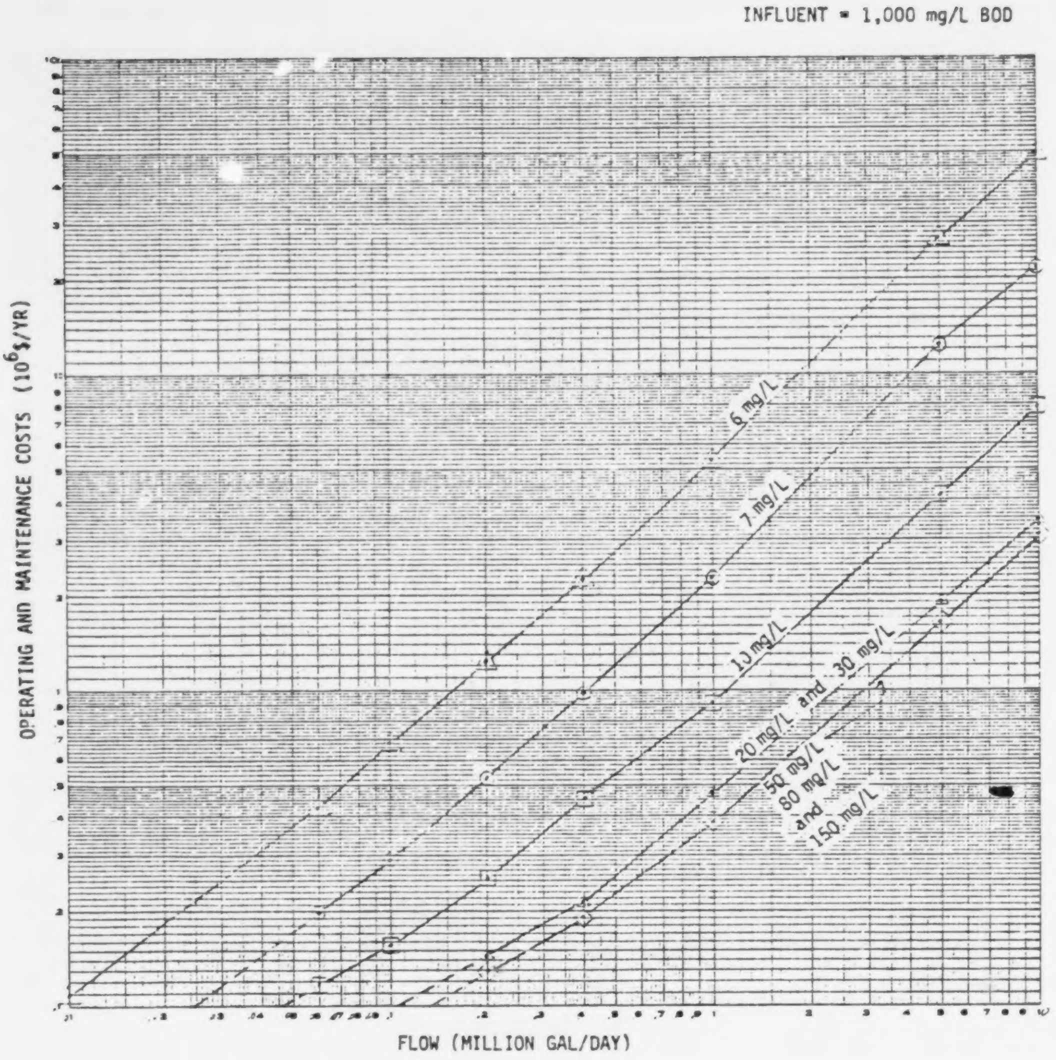


FIGURE 23—ACTIVATED SLUDGE OPERATING COSTS (1000 mg/l)

INFLUENT = 1,500 mg/L BOD

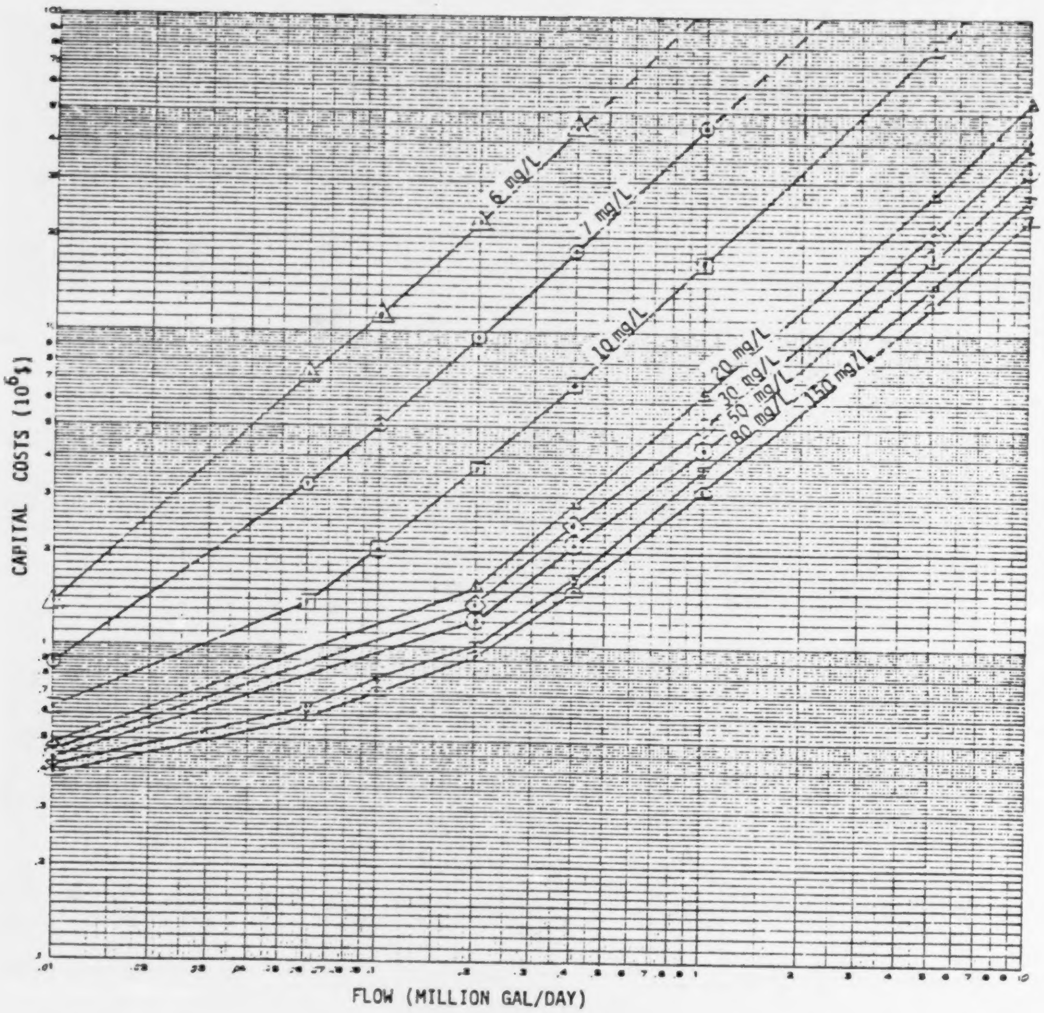


FIGURE 24—ACTIVATED SLUDGE ANNUAL COSTS (1500 mg/l)

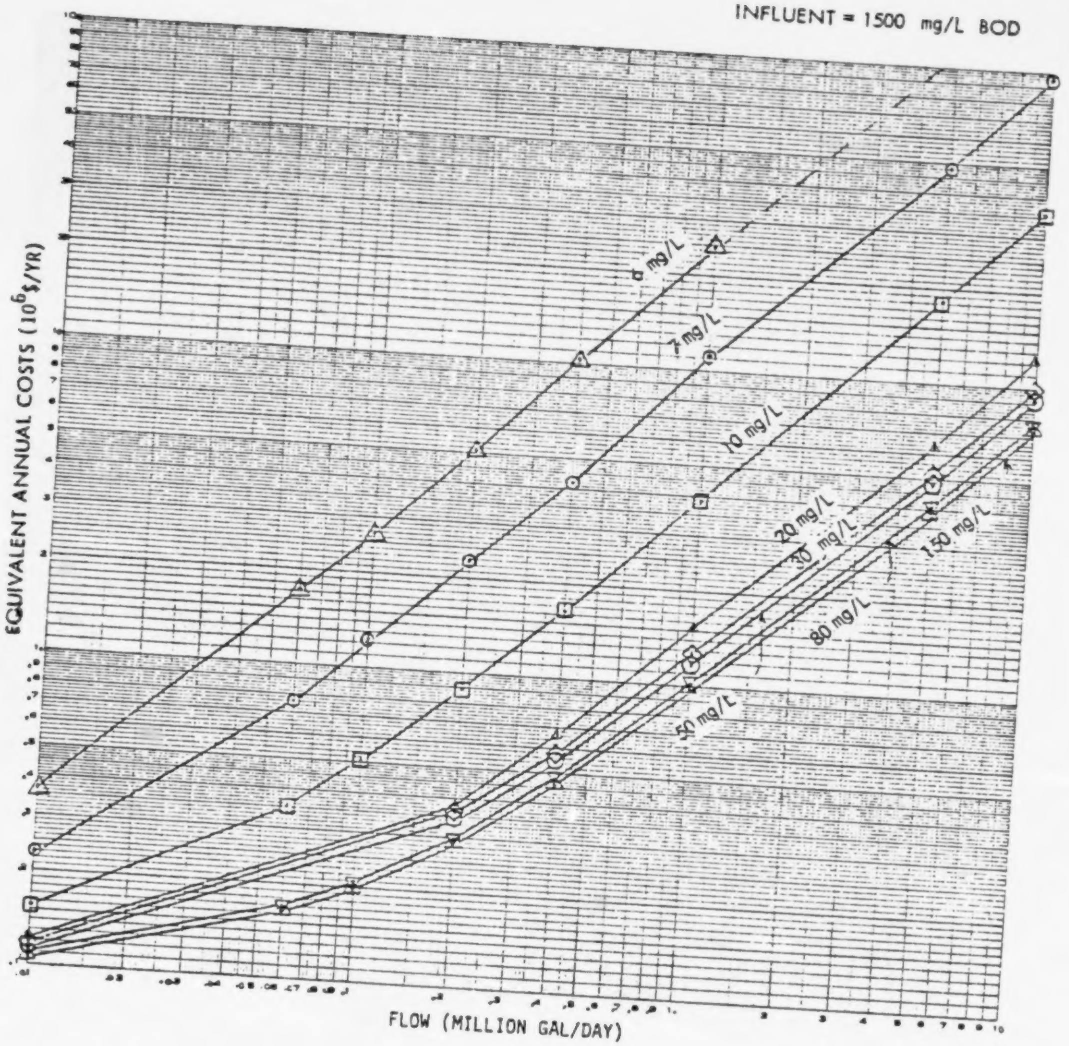


FIGURE 25—ACTIVATED SLUDGE CAPITAL COSTS (1500 mg/l)

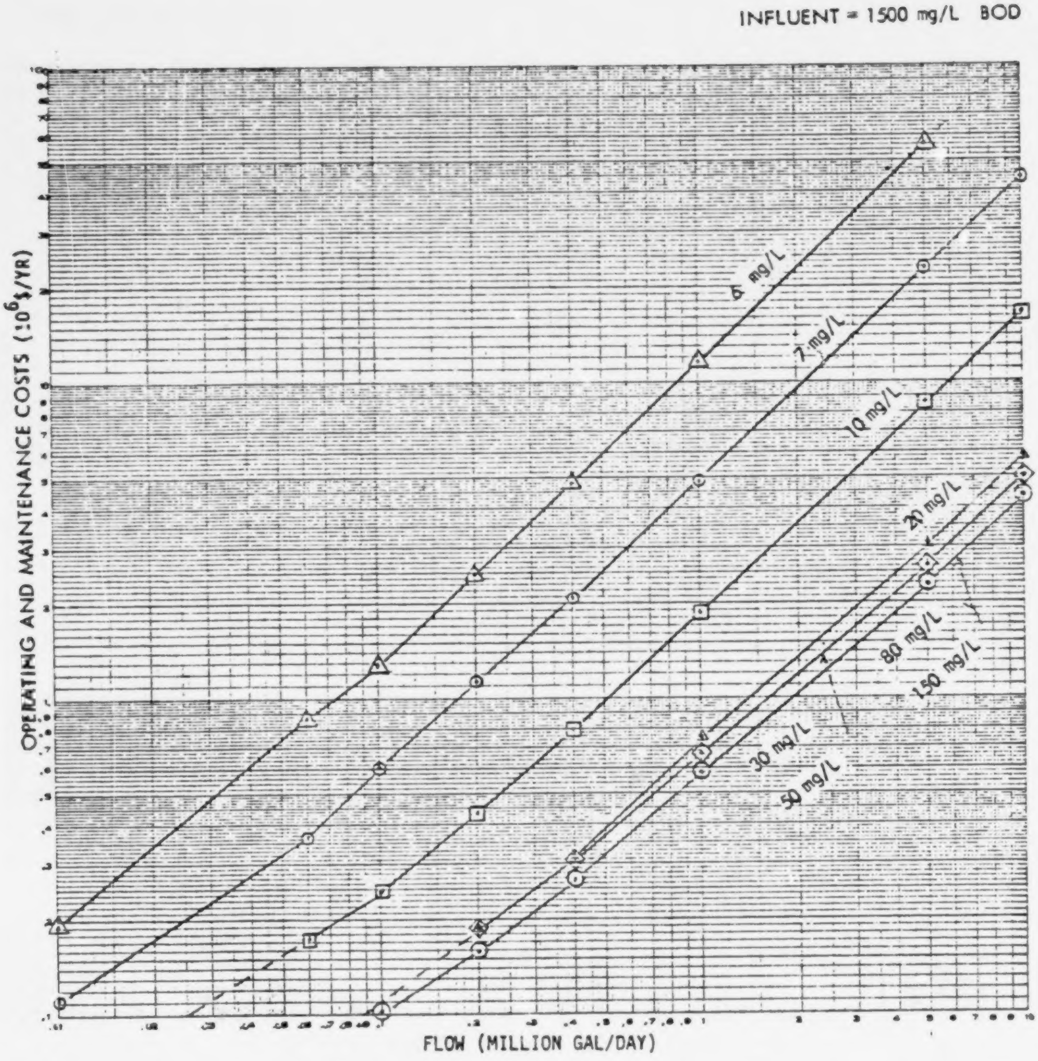


FIGURE 26—ACTIVATED SLUDGE OPERATING COSTS (1500 mg/l)

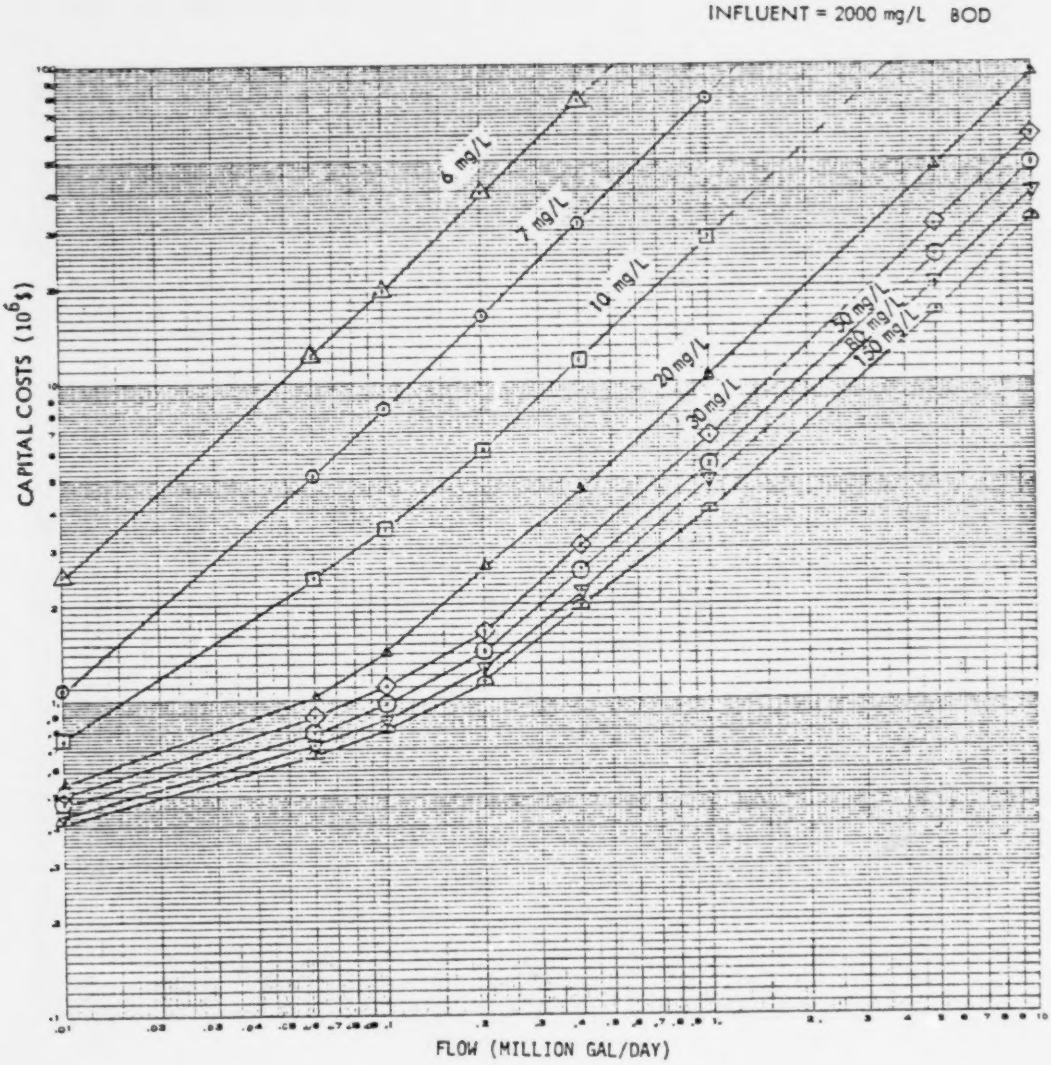


FIGURE 27—ACTIVATED SLUDGE ANNUAL COSTS (2000 mg/l)

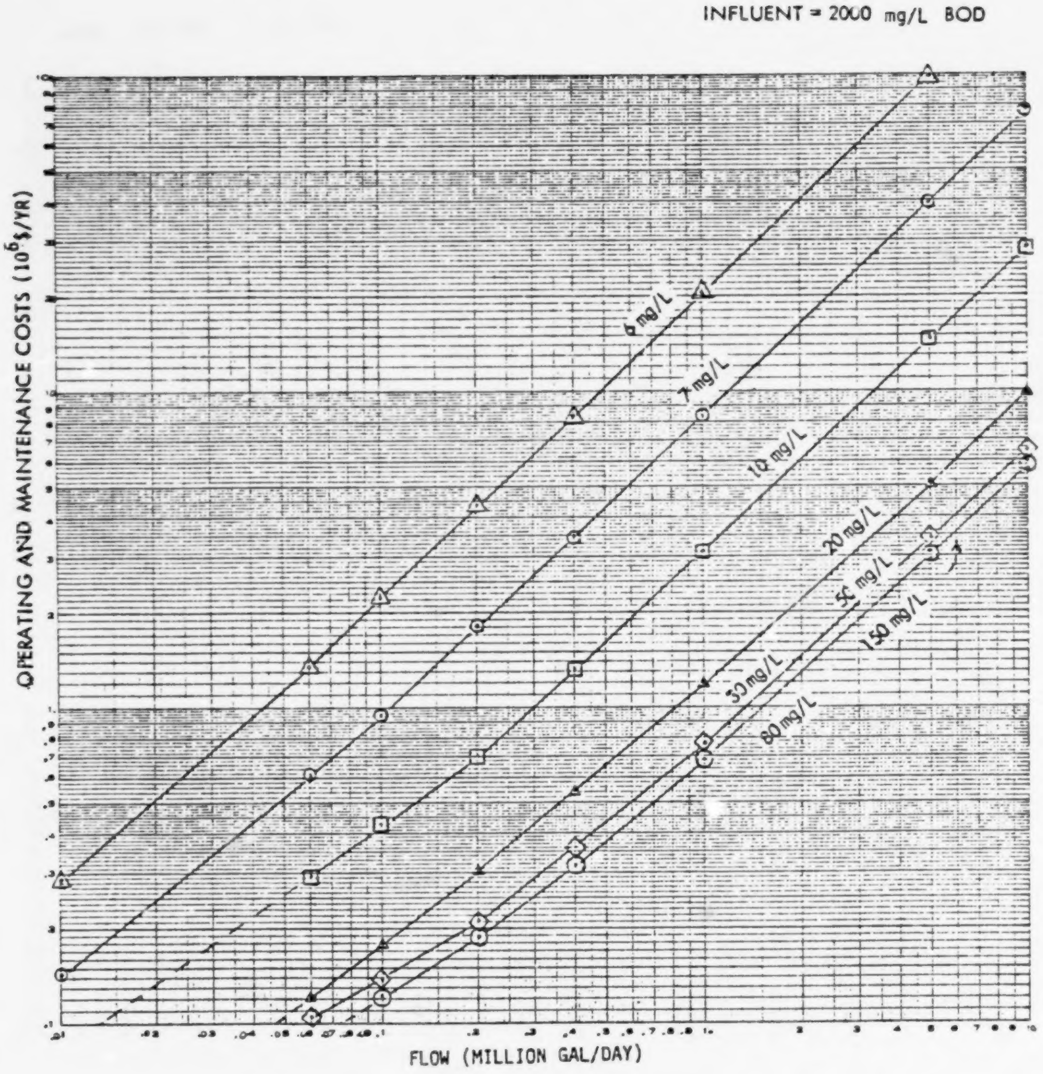


FIGURE 28—ACTIVATED SLUDGE CAPITAL COSTS (2000 mg/l)

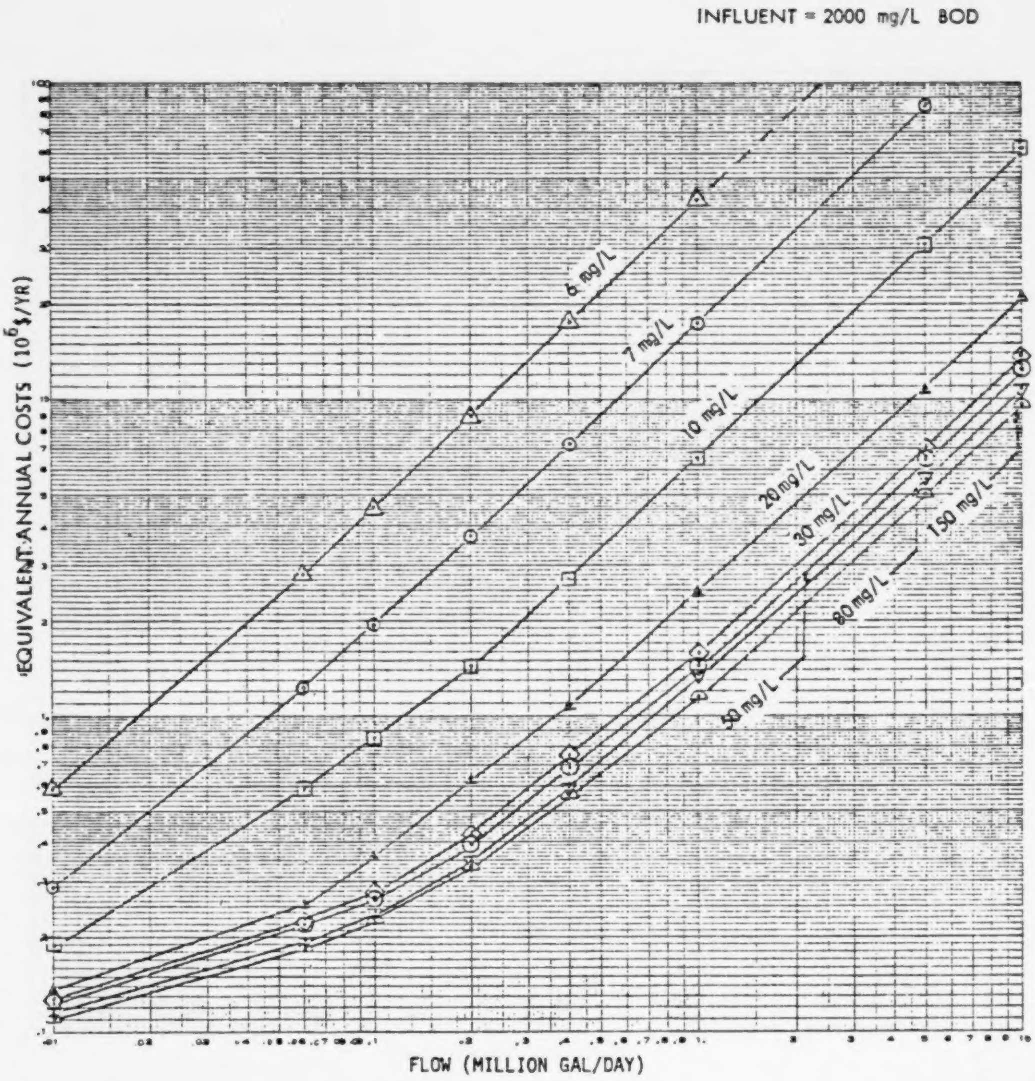


FIGURE 29—ACTIVATED SLUDGE OPERATING COSTS (2000 mg/l)

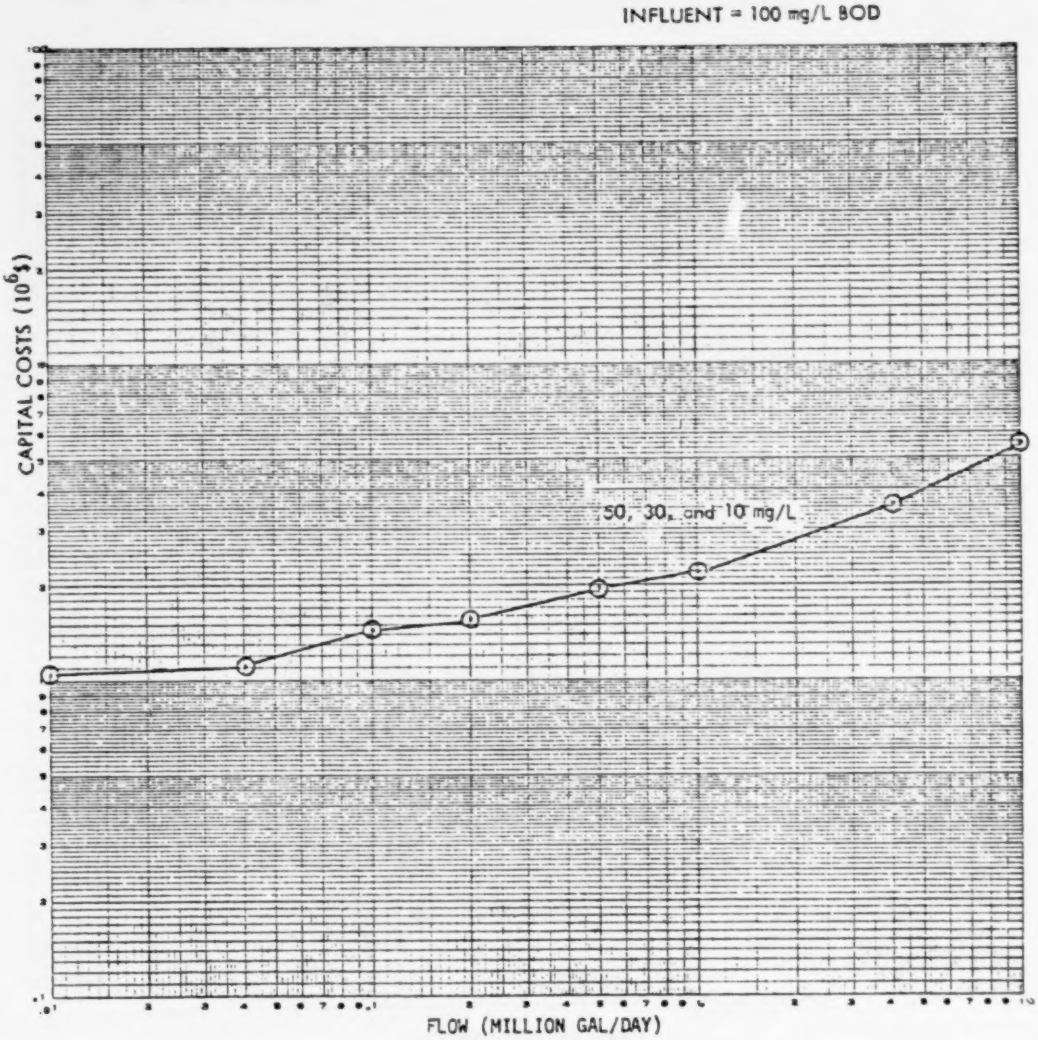


FIGURE 30—AERATED LAGOONS ANNUAL COSTS (100 mg/l)

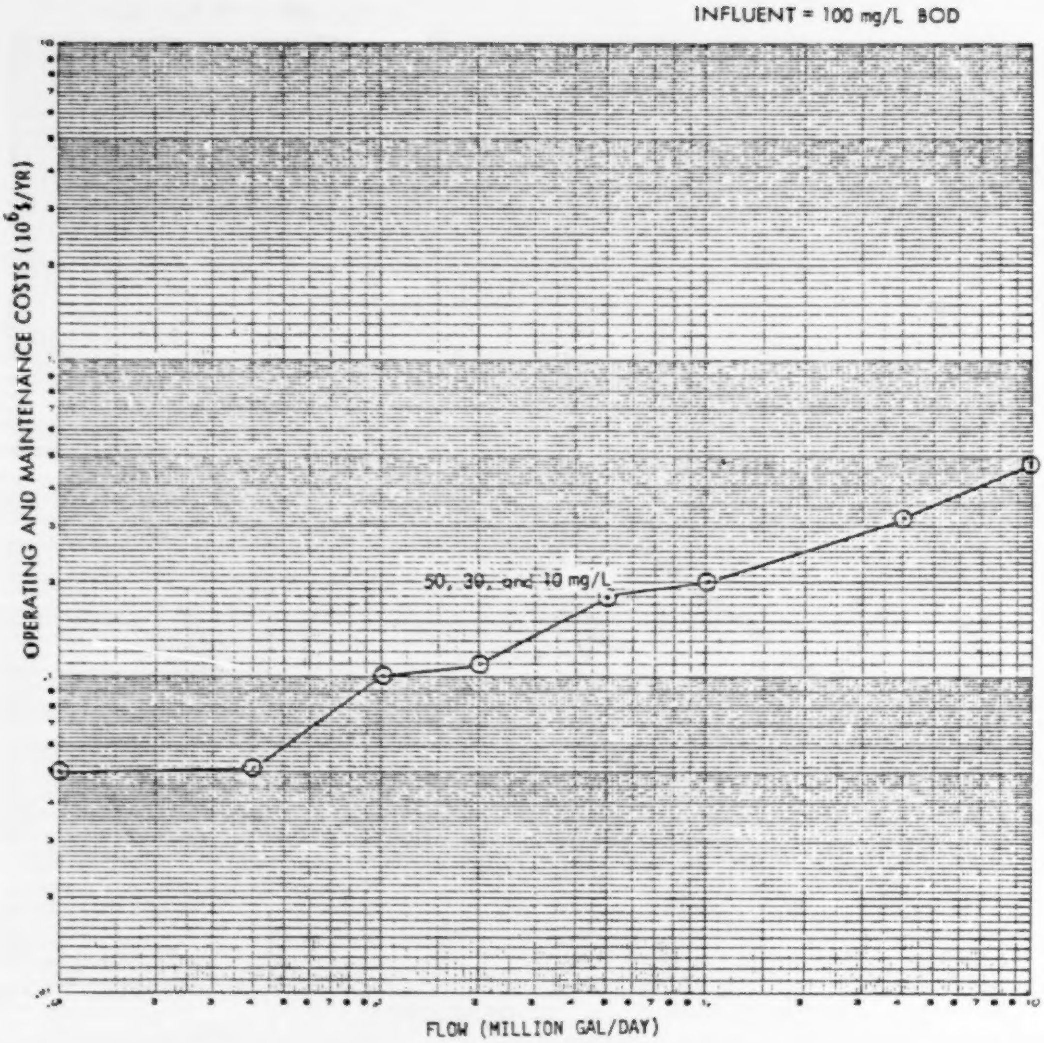


FIGURE 31—AERATED LAGOONS CAPITAL COSTS (100 mg/l)

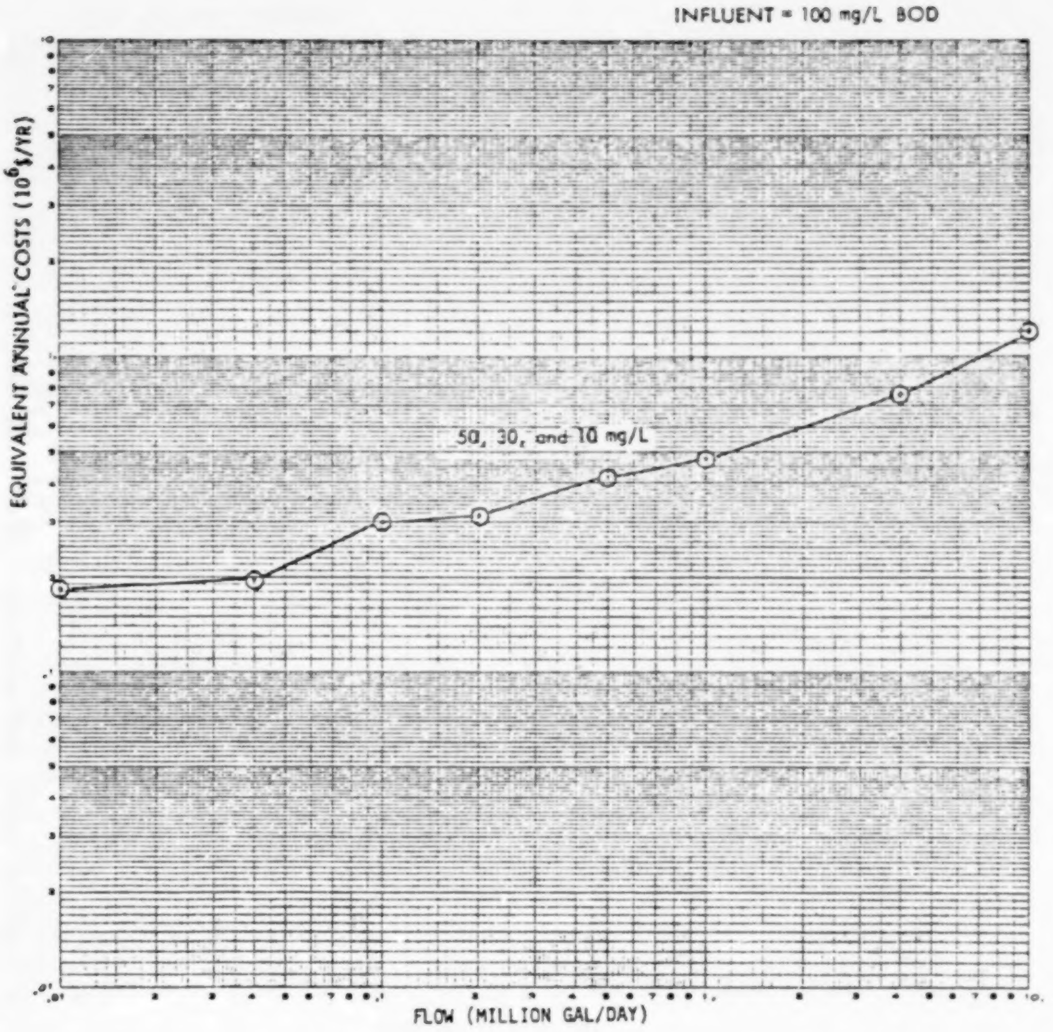


FIGURE 32—AERATED LAGOONS OPERATING COSTS (100 mg/l)

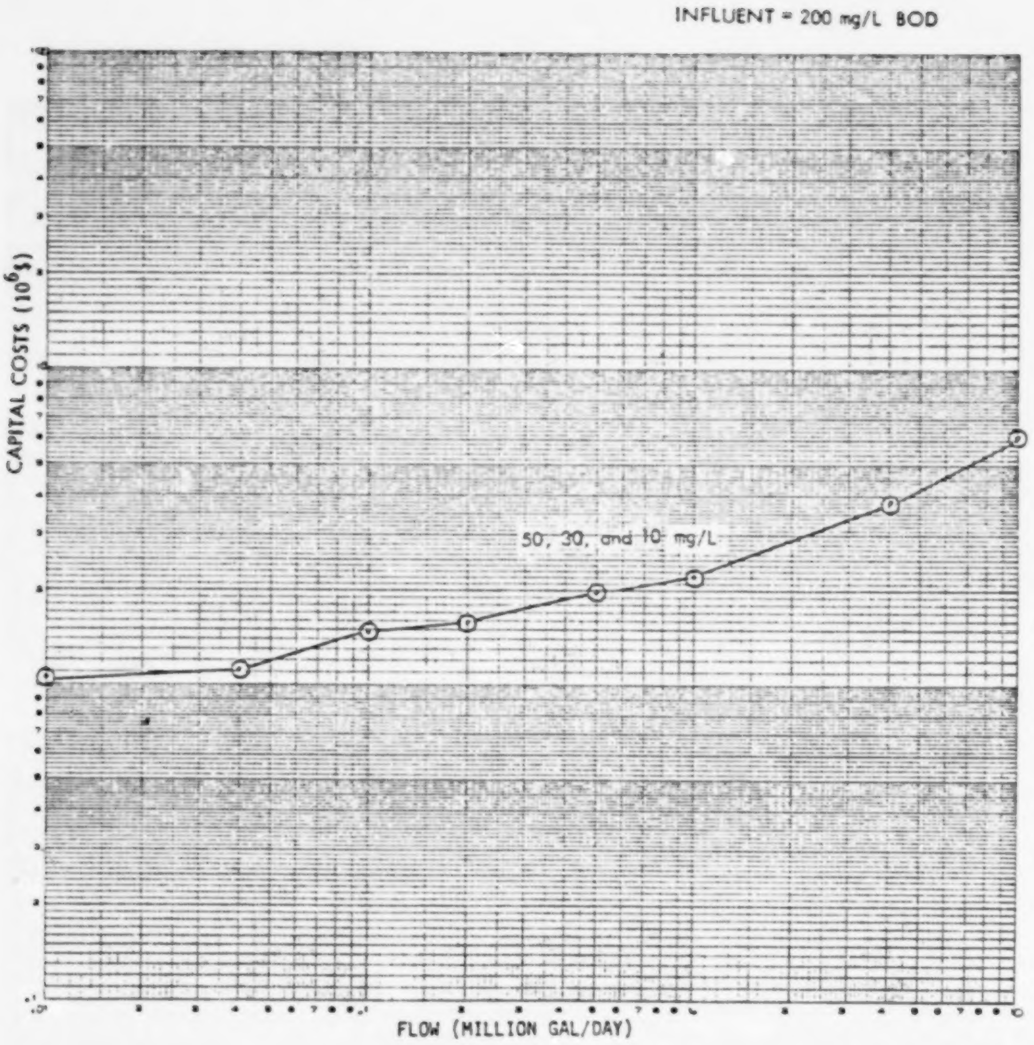


FIGURE 33

AERATED LAGOONS ANNUAL COSTS (200 mg/l)

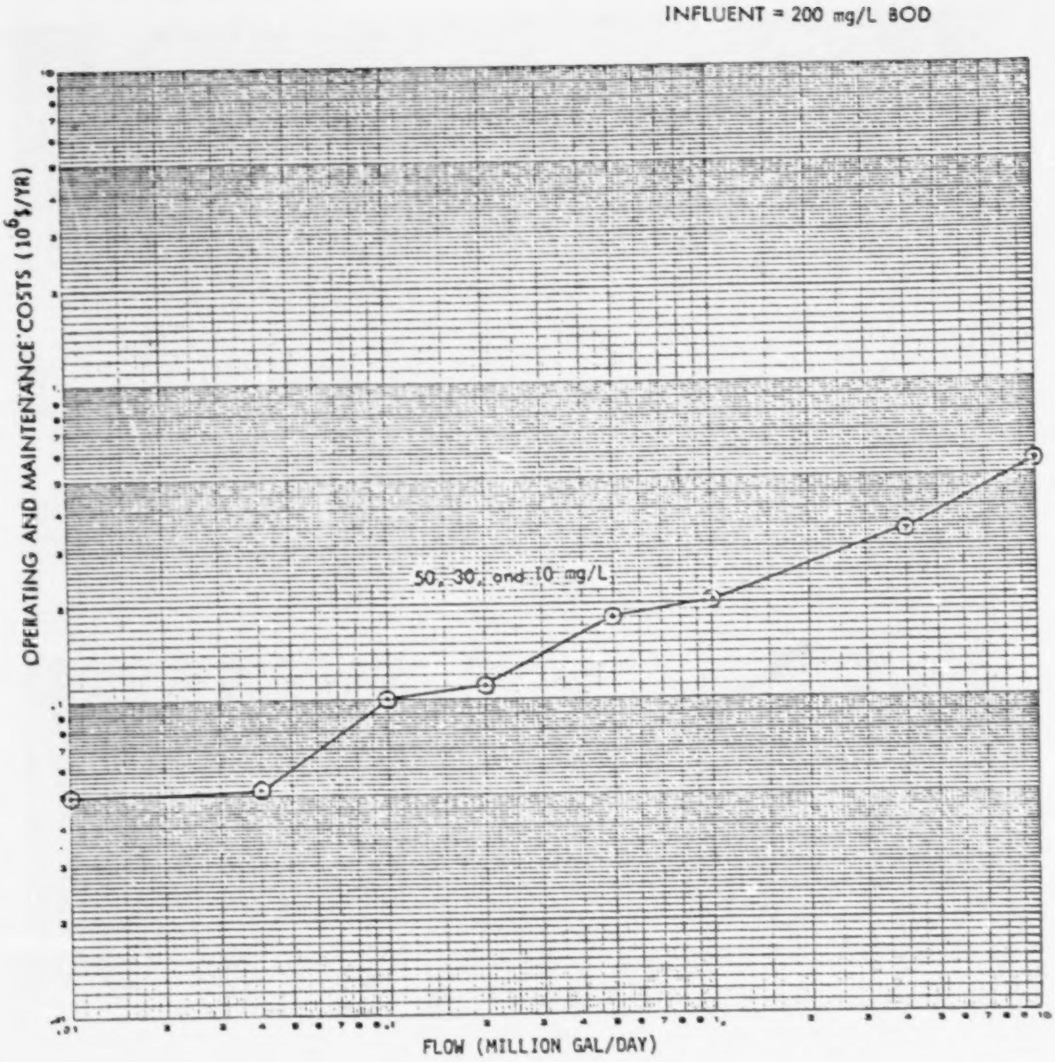


FIGURE 34—AERATED LAGOONS CAPITAL COSTS (200 mg/l)

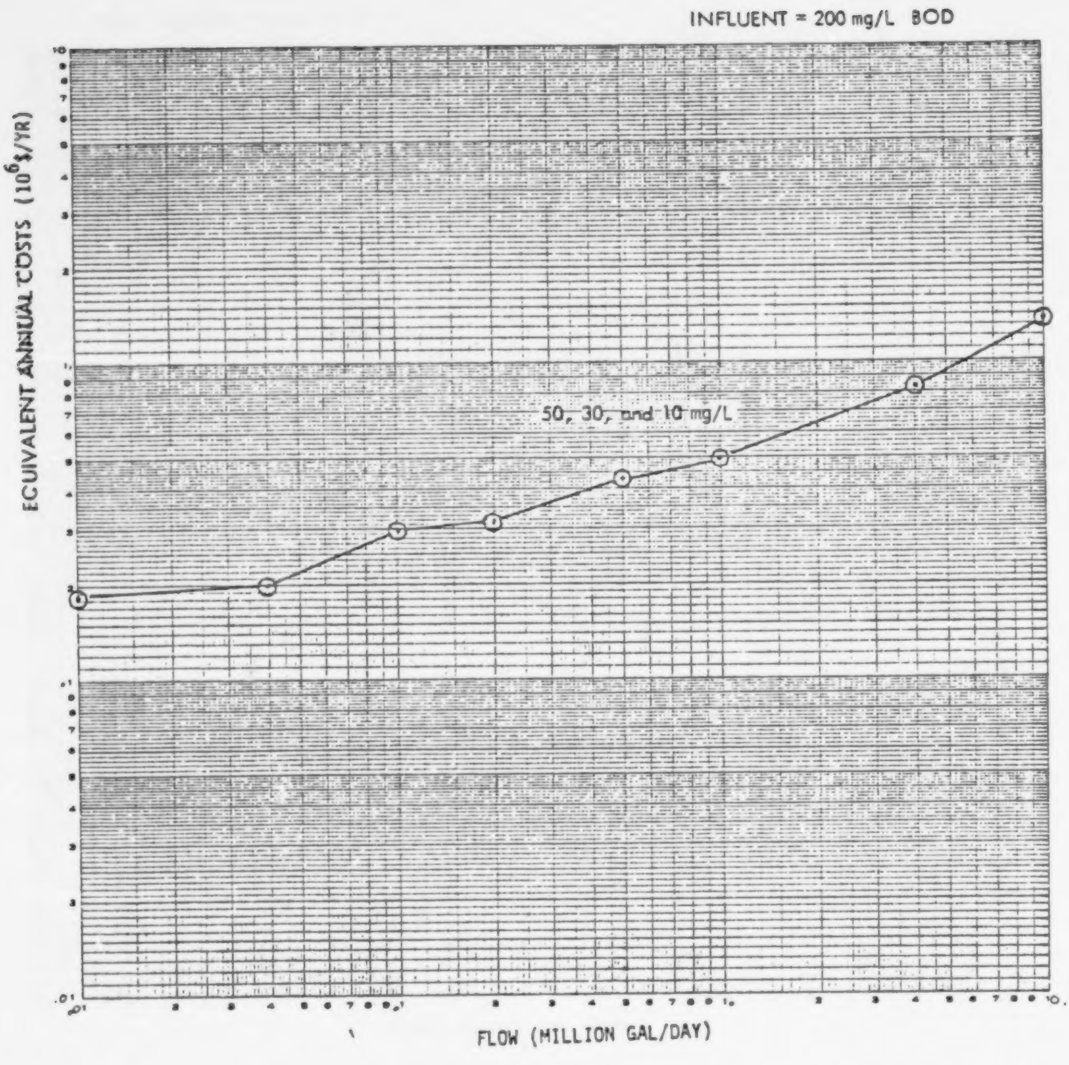


FIGURE 35—AERATED LAGOONS OPERATING COSTS (200 mg/l)

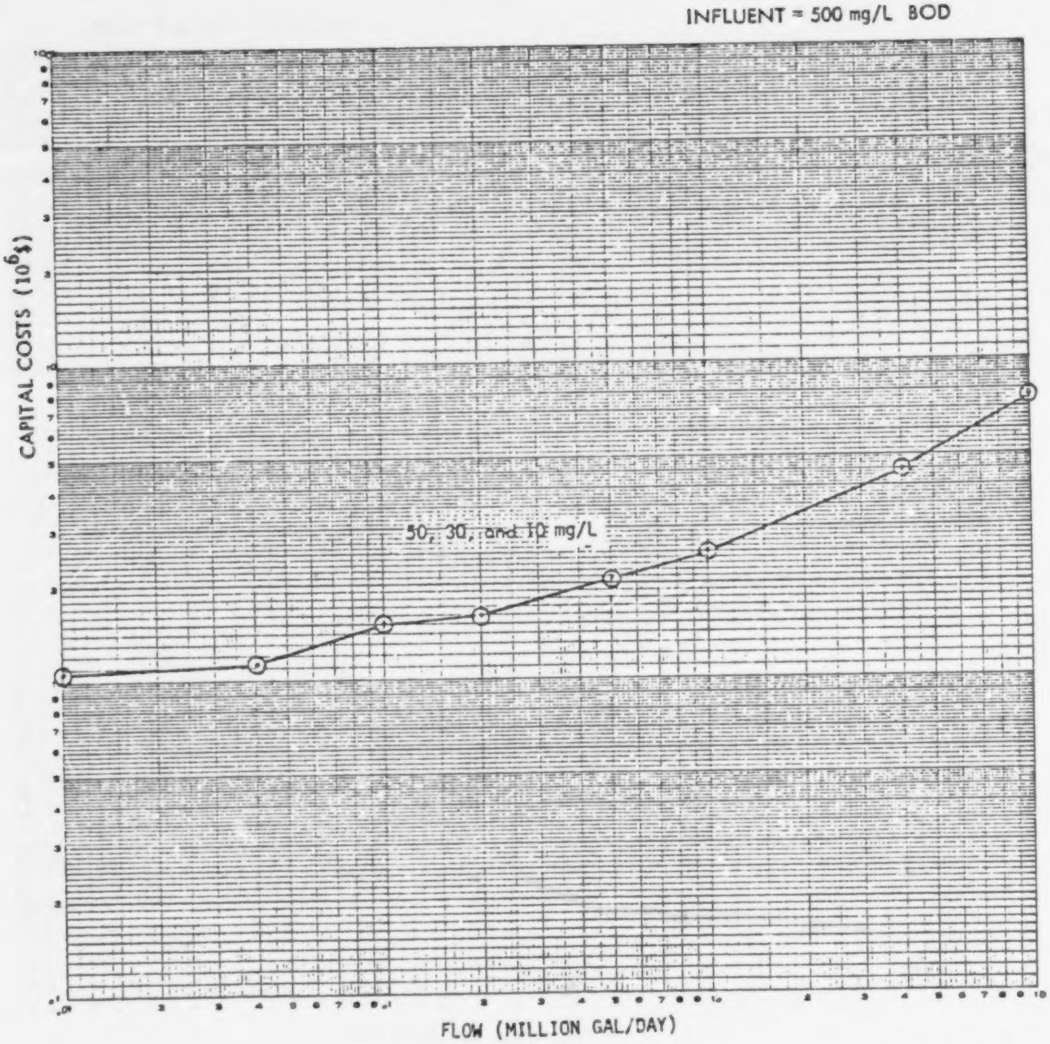


FIGURE 36—AERATED LAGOONS ANNUAL COSTS (500 mg/l)

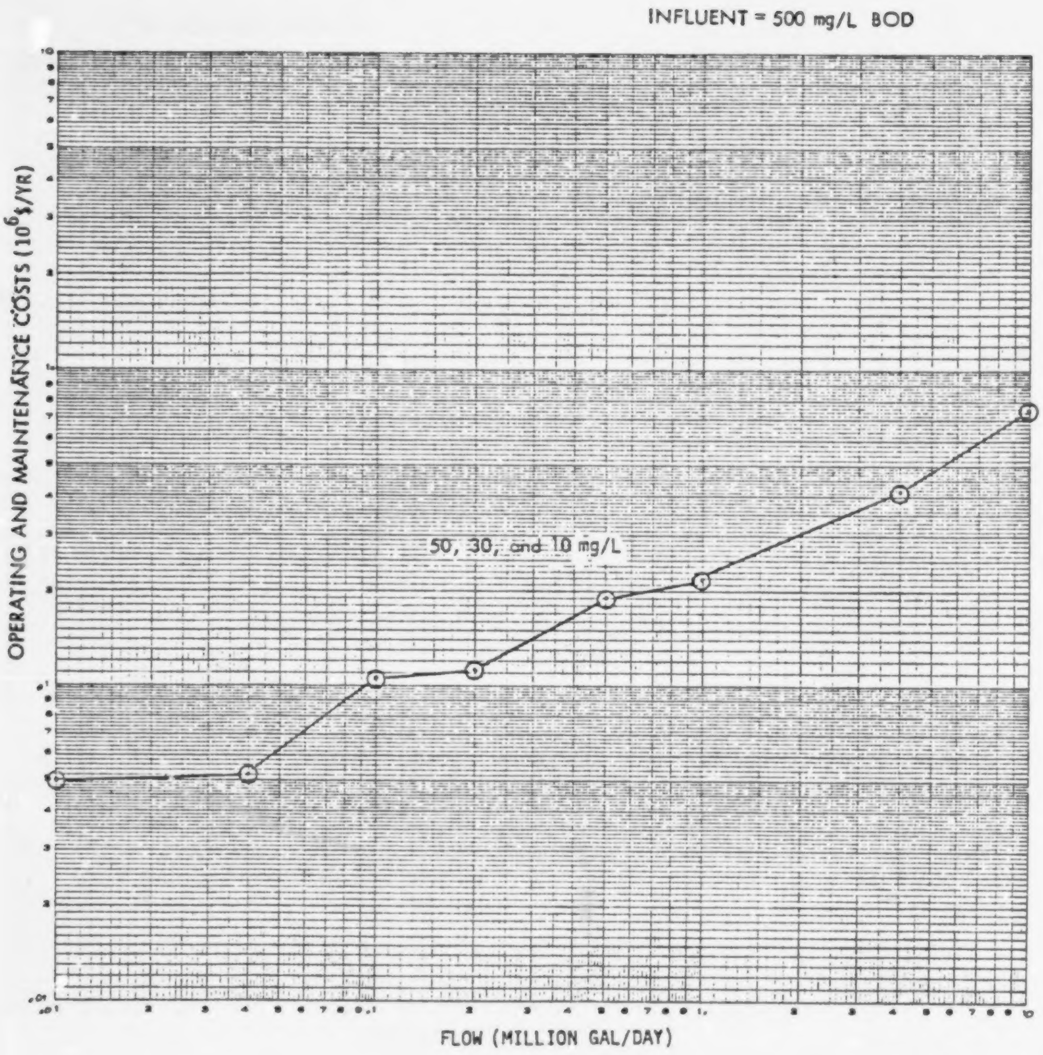


FIGURE 37—AERATED LAGOONS CAPITAL COSTS (500 mg/l)

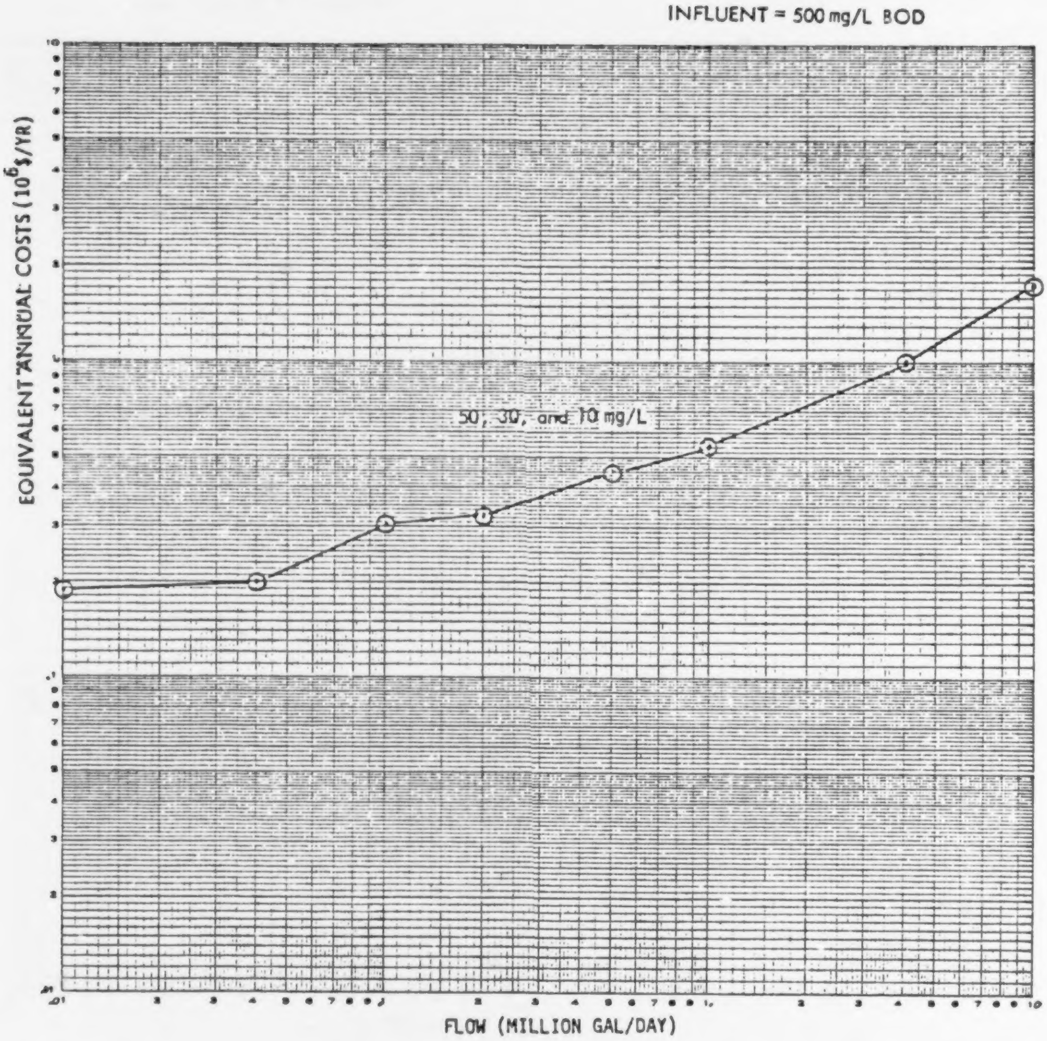


FIGURE 38—AERATED LAGOONS OPERATING COSTS (500 mg/l)

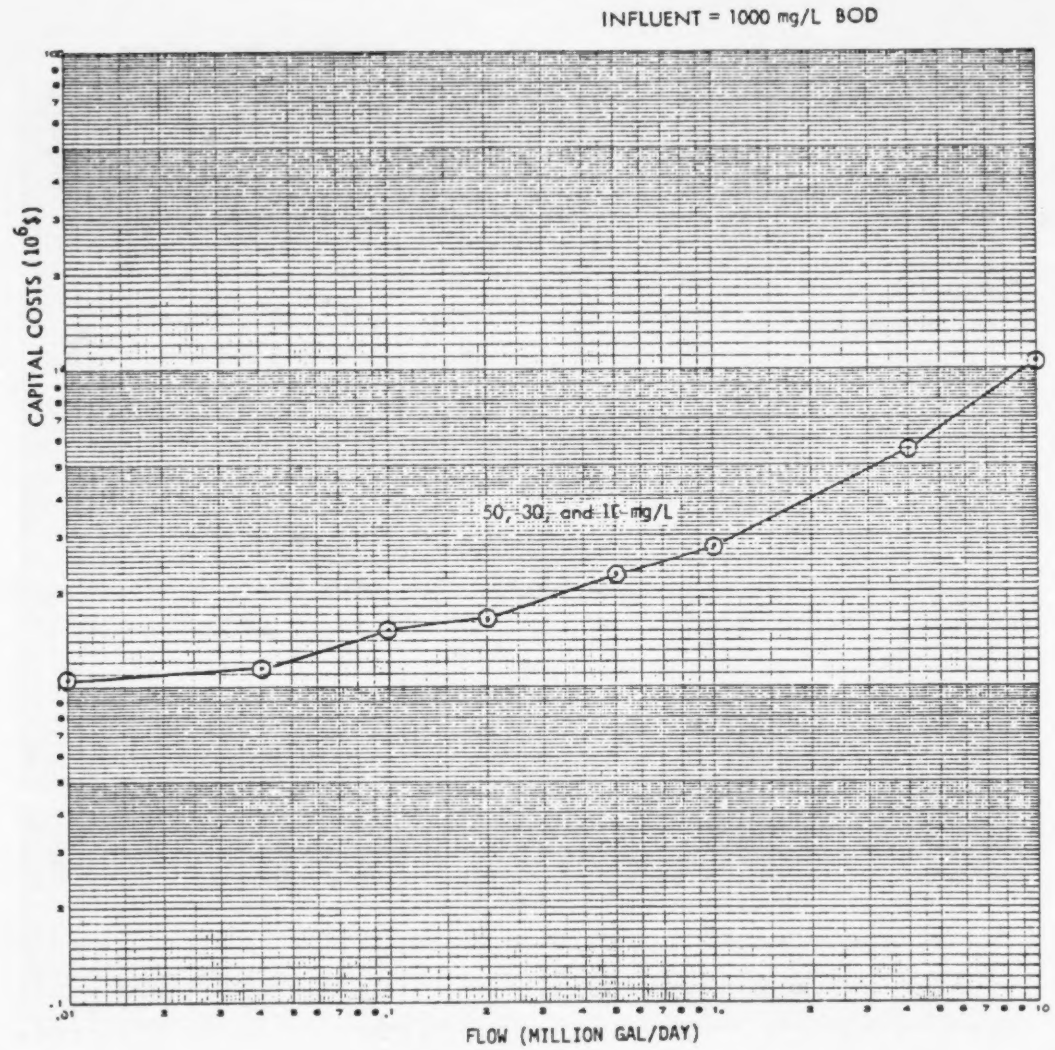


FIGURE 39—AERATED LAGOONS ANNUAL COSTS (1000 mg/l)

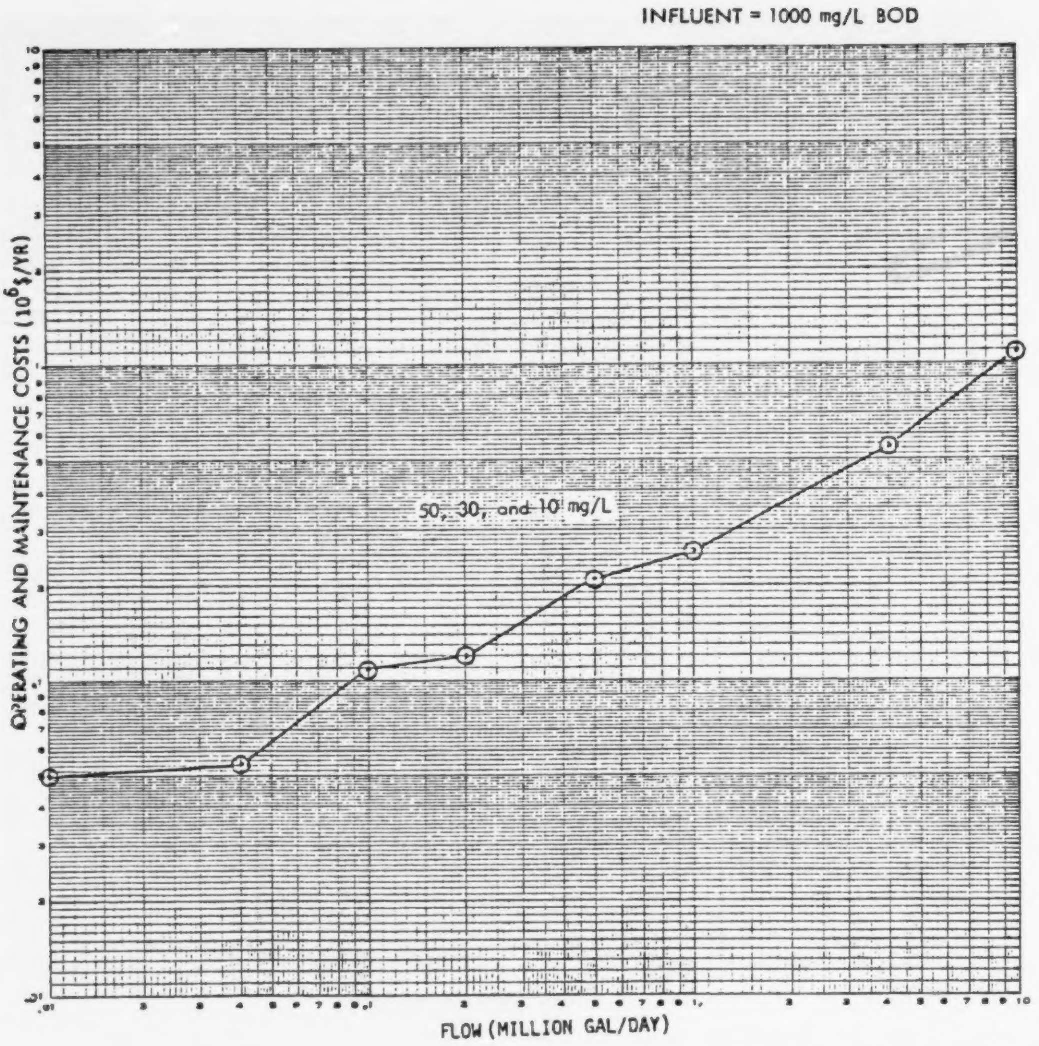


FIGURE 40—AERATED LAGOONS CAPITAL COSTS (1000 mg/l)

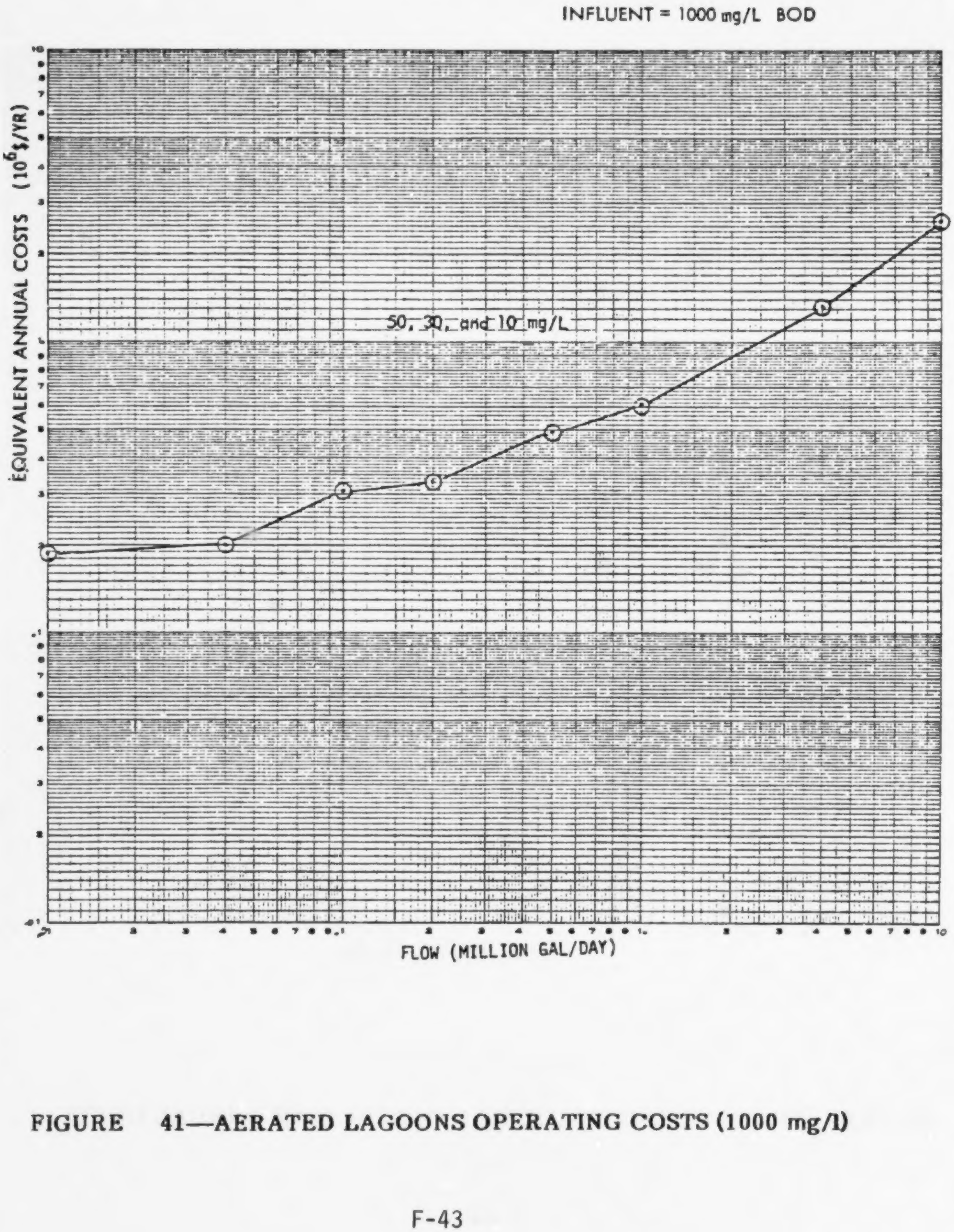


FIGURE 41—AERATED LAGOONS OPERATING COSTS (1000 mg/l)

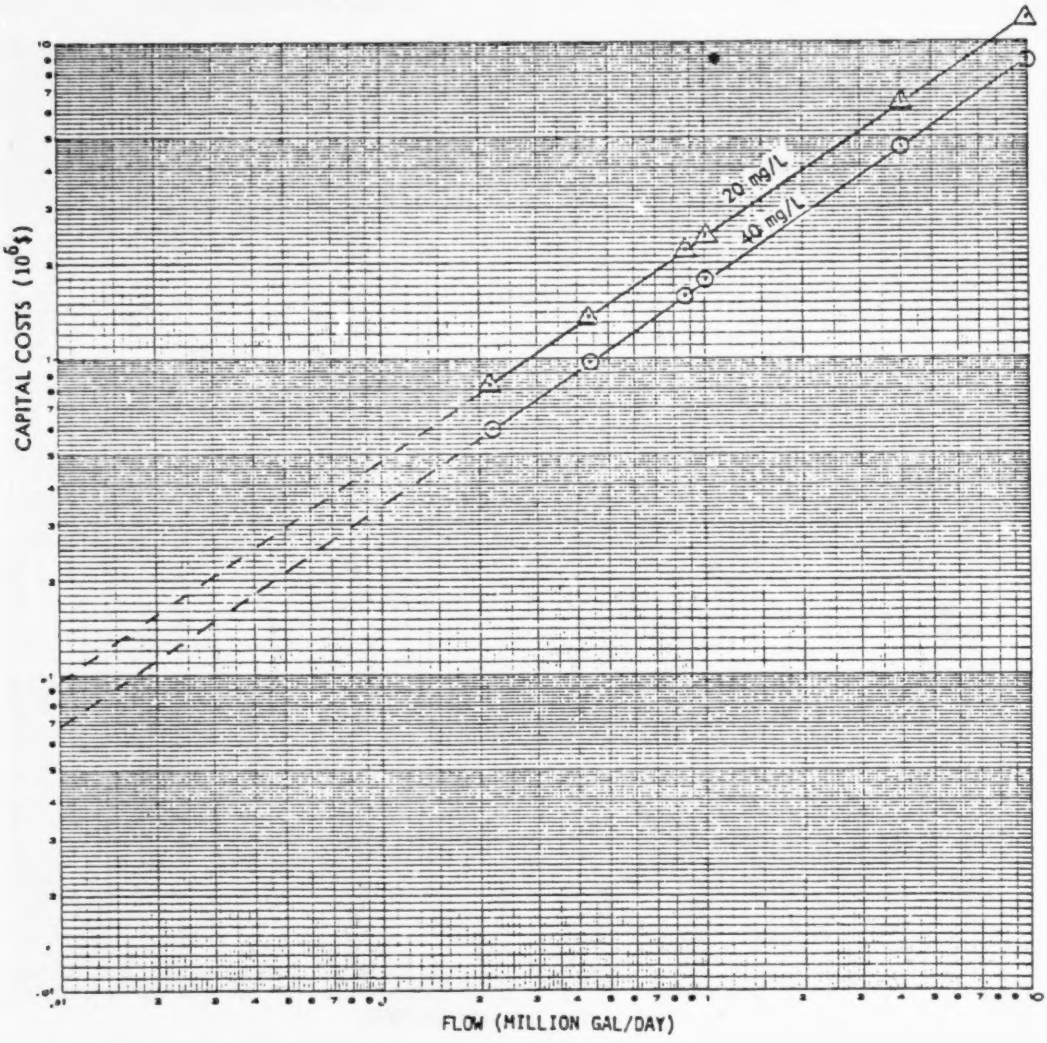


FIGURE 42—ROTATING BIOLOGICAL CONTACTORS ANNUAL COSTS

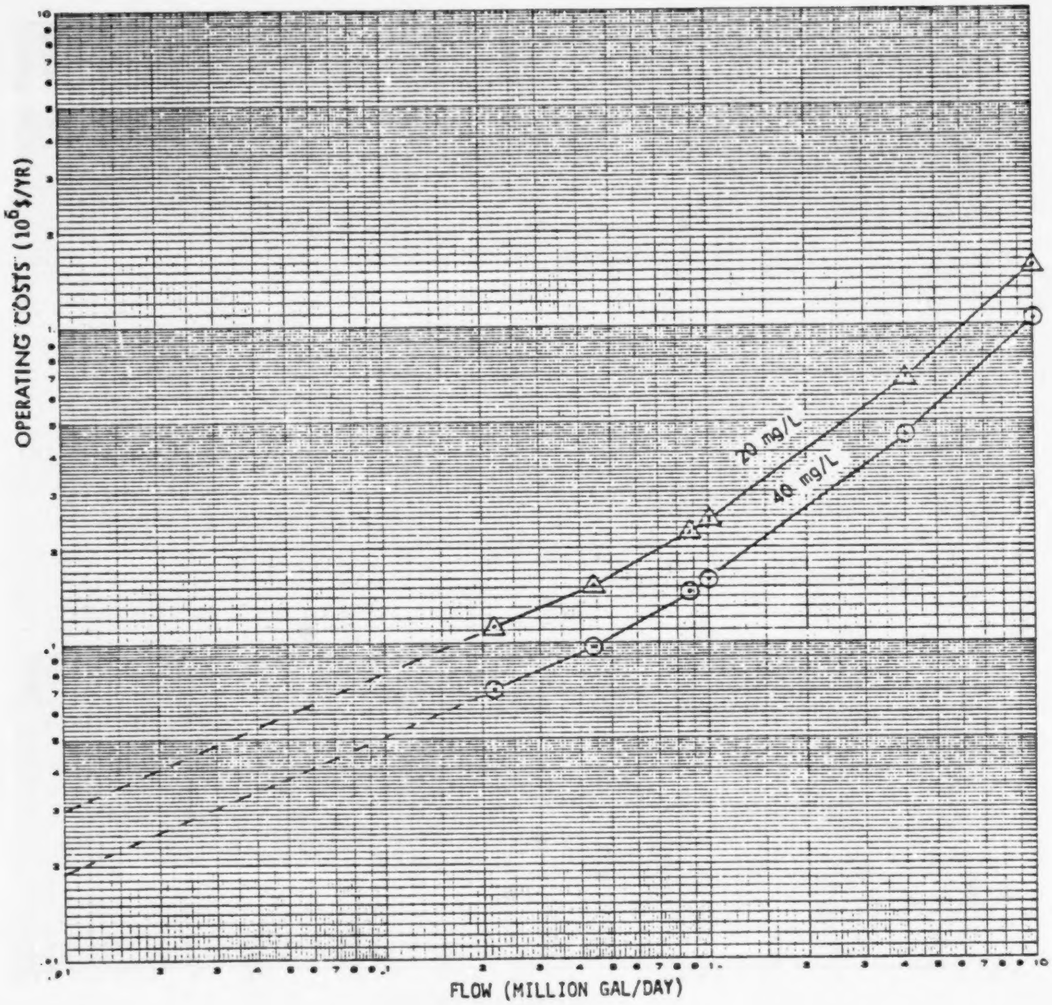


FIGURE 43—ROTATING BIOLOGICAL CONTACTORS CAPITAL COSTS

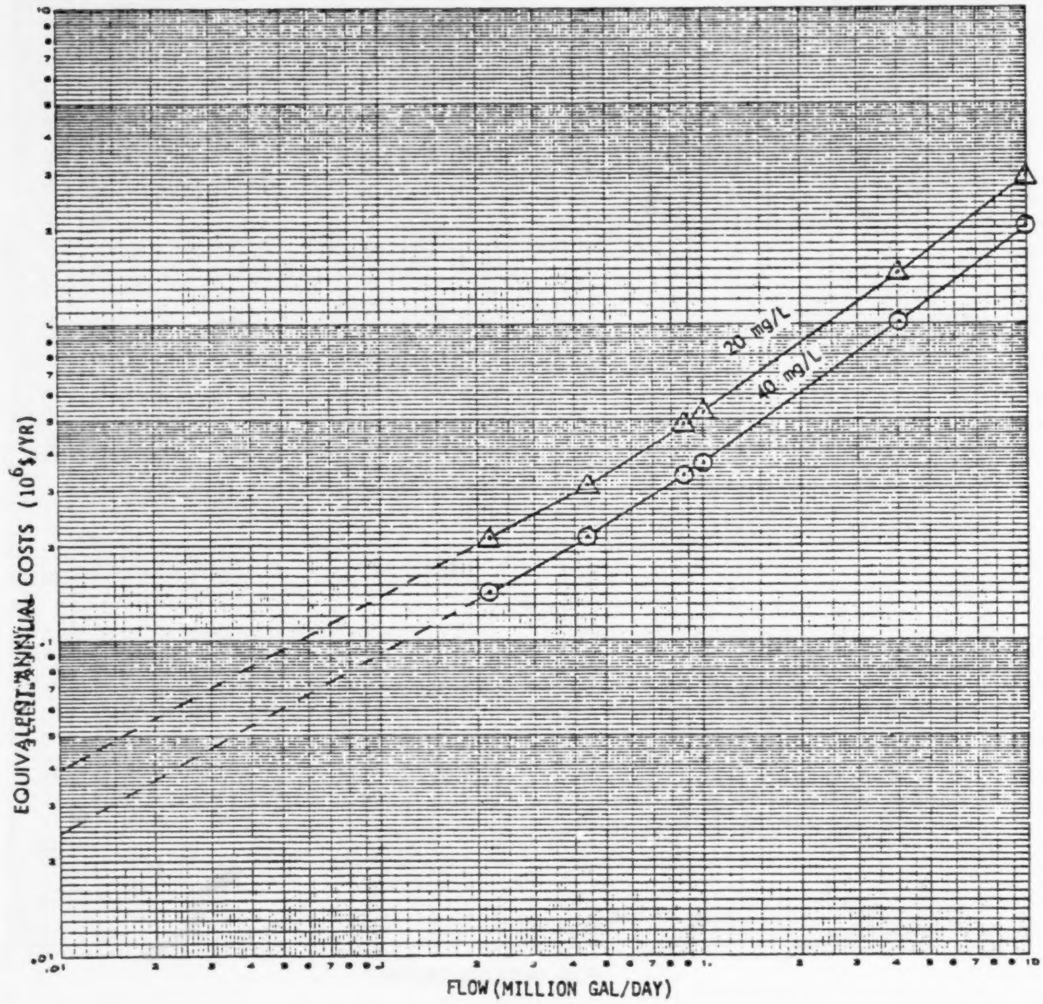


FIGURE 44—ROTATING BIOLOGICAL CONTACTORS OPERATING COSTS

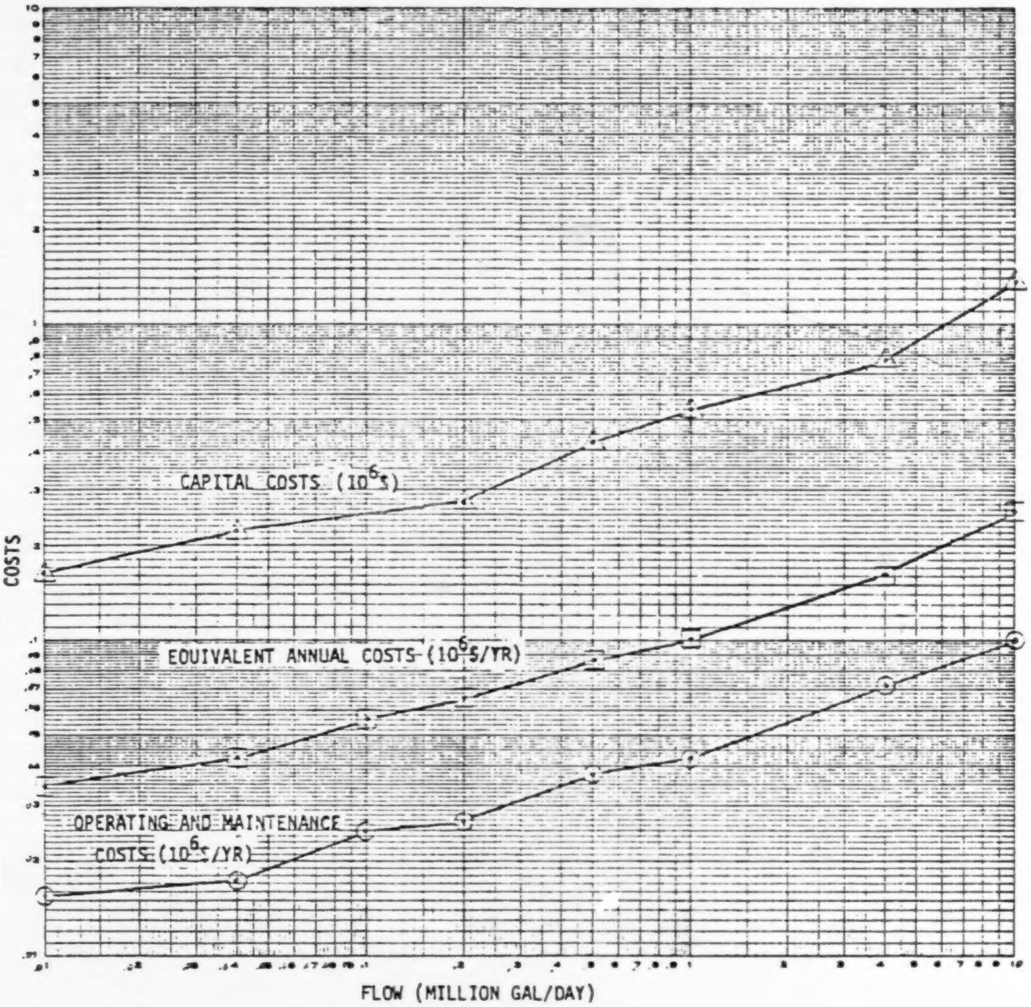


FIGURE 45

MULTI-MEDIA FILTRATION ANNUAL, CAPITAL AND OPERATING COSTS

APPENDIX G

Wastestream Data Listing

```
                                          WASTE STREAM
                                DATA LISTING - SUBCATEGORIZATION FILE
------------------------------------------------ SUBCAT=PLASTICS ONLY -----------------------------------------------

  PLANT                FLOWINF   FLOWEFF   BODINF     BODEFF    CODINF     CODEFF    TSSINF    TSSEFF    TOCINF    TOCEFF
  NUMBER*    # PP      (MGD)     (MGD)     (PPM)      (PPM)     (PPM)      (PPM)     (PPM)     (PPM)     (PPM)     (PPM)
  -----      -----     ------    ------    ------     ------    ------     ------    ------    ------    ------    ------

     2         2        1.83      1.83         .        3.00         .       10.00        .      27.00        .         .
     3         2        0.29      0.30     1394.00     45.00    2000.00     113.00     22.00     32.00    464.00     42.00
     4         3        0.07       .           .         .           .         .      237.00       .      31.00        .
     7         2        0.04       .      12542.00       .     18549.00        .     1055.00       .         .          .
     9         2        0.07      0.07      118.00      8.00         .           .      28.00     31.00       .      74.00
    10         3        0.71      0.76         .        7.00         .       30.00        .      14.00       .          .
    11         1         .         .           .         .           .           .        .         .         .          .
    11         .        0.50      0.20         .         .           .           .        .         .         .          .
    12         1         .         .           .         .           .           .        .         .         .          .
    13         2        2.00       .           .         .           .           .        .         .         .          .
    14         3        0.00       .           .         .           .           .        .         .         .          .
    17         3        0.05      0.05     1200.00     52.00    2376.00     188.00        .      30.00       .          .
    17         3         .         .           .         .           .           .        .         .         .          .
    19         8        3.80      3.80      237.00      7.00     470.00        .          .      15.00       .          .
    25         4        0.17      0.16        9.00       .        42.00      42.00     31.00     12.00      9.00        .
    27         5       10.60     10.70      131.00     23.00     258.00     120.00     38.00     25.00       .          .
    29         2        8.70      8.70      114.00      7.00     210.00     115.00     86.00    114.00       .      17.00
    30         3        0.04       .           .         .           .           .        .         .         .          .
    33         1        5.24      5.22         .         .           .           .        .         .         .          .
    34         1        0.08      0.06      666.00     35.00    1669.00     194.00        .      23.00       .          .
    35         1        0.70       .        388.00       .       416.00        .        0.30       .         .          .
    39         4        0.39      0.39         .        6.00         .           .        .       9.00       .          .
    44         1        0.67      0.67      754.00      9.00    1234.00      83.00   2898.00     22.00       .          .
    45         2        2.22      2.22      390.00      3.00     639.00      57.00    285.00     24.00       .          .
    46         2         .         .           .         .           .           .        .         .         .          .
    47         5         .         .           .         .           .           .        .         .         .          .
    47         .         .         .           .         .           .           .        .         .         .          .
    48         1         .         .           .         .           .           .        .         .         .          .
    52         2        0.86      0.86      104.00      8.00         .       67.00        .      13.00       .          .
    54         1        0.20      0.22      424.00     30.00     857.00     118.00     49.00     43.00       .          .
    56         1        0.01       .       1861.00       .      6082.00        .      280.00       .    1938.00        .
    58         1         .         .           .         .           .           .        .         .         .          .
    62         .        0.00       .           .         .           .           .        .         .         .          .
    65         3        8.70      8.70      349.00     18.00     710.00     110.00    153.00     52.00       .          .
    67         1         .         .           .         .           .           .        .         .         .          .
    68         2         .         .           .         .           .           .        .         .         .          .
    70         2         .         .           .         .           .           .        .         .         .          .
    73         3        0.25      0.25       14.00      3.00     473.00      38.00   1359.00     11.00       .          .
```

*Note: Each line entry represents a separate waste stream. Plant code numbers are repeated for plants with multiple waste streams.

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                                         WASTE STREAM
                            DATA LISTING - SUBCATEGORIZATION FILE
---------------------------------------- SUBCAT=PLASTICS ONLY ----------------------------------------

PLANT             FLOWINF   FLOWEFF   BODINF    BODEFF   CODINF    CODEFF   TSSINF    TSSEFF   TOCINF   TUCEFF
NUMBER    # PP    (MGD)     (MGD)     (PPM)     (PPM)    (PPM)     (PPM)    (PPM)     (PPM)    (PPM)    (PPM)
-----     -----   ------    ------    ------    ------   ------    ------   ------    ------   ------   ------

  75        2      0.42      0.42     170.00    24.00    876.00   176.00       .         .        .        .
  77        4      0.94      0.94       2.00     2.00     27.00    27.00     10.00     10.00       .        .
  77        .      0.01        .      895.00       .      48.00       .      16.00        .        .        .
  77        .        .         .         .         .        .         .         .         .        .        .
  78        1        .         .         .         .        .         .         .         .        .        .
  79        2      0.03        .         .         .        .         .         .         .        .        .
  82        3        .         .         .         .        .         .         .         .        .        .
  82        .        .         .         .         .        .         .         .         .        .        .
  84        1      0.14      0.14        .         .        .         .         .         .        .        .
  84        1      0.68      0.68        .         .        .         .         .         .        .        .
  89        4      1.71      1.71     979.00    40.00   1908.00   620.00    101.00     76.00       .        .
  90        2      2.74      2.74      51.00     4.00     97.00    15.00     20.00     15.00       .        .
  91        2      2.06      2.06     174.00    10.00    329.00    69.00     79.00     84.00       .        .
  91        .      0.47        .         .         .        .         .         .         .        .        .
  93        1      0.12      0.12      80.00    15.00    504.00   146.00    205.00     78.00       .        .
  96        1      3.00      3.00     128.00     3.00       .         .      24.00     19.00       .        .
 100        1      1.00      1.00     424.00    15.00    607.00    98.00    106.00     37.00       .        .
 100        1      0.85      0.85        .      10.00       .         .         .       4.00       .        .
 104        7      1.54      1.54    1082.00    11.00   1557.00   115.00     62.00     60.00   434.00    45.00
 104        .      0.10        .         .         .        .         .         .         .        .        .
 104        .        .         .         .         .        .         .         .         .        .        .
 104        .        .         .         .         .        .         .         .         .        .        .
 105        1      0.30      0.30    1847.00     6.00   2689.00   131.00     61.00     35.00       .        .
 106        6      5.95      5.95      94.00    11.00    179.00    53.00        .         .        .        .
 107        1      2.16      2.55     215.00    47.00    403.00   172.00    142.00    127.00       .        .
 109        3      1.57      1.57     427.00    12.00    864.00       .     151.00     83.00   290.00    96.00
 111        1      0.93      0.93      95.00     6.00    272.00    37.00     43.00     10.00       .        .
 119        1      1.65      1.65      12.00    10.00     73.00    58.00     36.00     26.00    25.00    19.00
 123        2      0.28      0.28        .         .      807.00    96.00     81.00     18.00       .        .
 124        2      0.38      0.38     568.00    37.00    874.00    61.00     83.00     22.00       .        .
 125        2      0.52      0.52    1764.00    45.00   3173.00   205.00    187.00     30.00       .        .
 126        3      0.35      0.35    1021.00     8.00   2292.00   102.00    561.00     28.00       .        .
 129        3        .         .         .         .        .         .         .         .        .        .
 131        1      0.00        .         .         .        .         .         .         .        .        .
 132        1      0.28      0.28        .      21.00       .      130.00       .      13.00       .        .
 140        2        .         .         .         .        .         .         .         .        .        .
 140        .        .         .         .         .        .         .         .         .        .        .
 146        5      0.35      0.35     187.00     6.00   1681.00    45.00   2547.00     23.00       .        .
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                                              WASTE STREAM
                                 DATA LISTING - SUBCATEGORIZATION FILE

------------------------------------------------------ SUBCAT=PLASTICS ONLY ------------------------------------------------------

 PLANT               FLOWINF    FLOWEFF    BODINF     BODEFF     CODINF     CODEFF     TSSINF     TSSEFF     TOCINF     TOCEFF
 NUMBER    # PP      (MGD)      (MGD)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)
 -----     -----     ------     ------     ------     ------     ------     ------     ------     ------     ------     ------

  147        3        0.30       0.29     1000.00      9.00     2152.00     80.00     868.00     29.00        .          .
  148        1         .          .           .         .           .         .          .          .          .          .
  150        6        0.58       0.63      447.00     43.00         .      124.00         .       11.00        .          .
  152        1        1.96       1.96         .        7.00         .       58.00         .       21.00        .          .
  152        1        0.06       0.06         .        4.00         .       49.00         .       16.00        .          .
  154        3        0.07        .           .         .           .         .          .          .          .          .
  155        6         .          .           .         .           .         .          .          .          .          .
  155        .       10.70        .           .         .           .         .          .          .          .          .
  155        .        0.50        .           .         .           .         .          .          .          .          .
  156        2        1.06       0.06         .         .           .         .        14.00        .          .          .
  157        1        1.72       1.31         .       18.00         .       37.00         .       52.00        .          .
  161        2         .          .           .         .           .         .          .          .          .          .
  167        1        0.00        .           .         .           .         .          .          .          .          .
  168        1         .          .           .         .           .         .          .          .          .          .
  173        5        0.00        .        8500.00       .           .         .          .          .       800.00        .
  174        7        0.09       0.09      372.00      9.00     1178.00     62.00         .       14.00        .          .
  179        3        0.48       0.48      378.00     10.00     1195.00    190.00      78.00     37.00        .          .
  184        4        1.02       1.02         .       16.00         .       65.00         .       26.00        .          .
  185        1         .          .           .         .           .         .          .          .          .          .
  189        1        0.32       0.32         .       86.00         .      334.00         .       38.00        .          .
  192        3        0.13       0.11      883.00     21.00     1686.00    186.00         .       90.00     1578.00       .
  194        2        0.39       0.39        7.00      7.00         .         .        10.00     10.00        .          .
  196        1        3.70       3.70       50.00     24.00      218.00    127.00      31.00     17.00        .          .
  197        3         .          .           .         .           .         .          .          .          .          .
  197        1         .          .           .         .           .         .          .          .          .          .
  198        1         .          .           .         .           .         .          .          .          .          .
  199        4         .          .           .         .           .         .          .          .          .          .
  199        1         .          .           .         .           .         .          .          .          .          .
  200        1        0.00        .           .         .           .         .          .          .          .          .
  200        .        0.00        .           .         .           .         .          .          .          .          .
  202        1        0.15       0.15         .       20.00         .       85.00         .       16.00        .          .
  207        2         .          .           .         .           .         .          .          .          .          .
  209        1        0.00        .           .         .           .         .          .          .          .          .
  210        8        1.27       1.27         .        9.00         .       36.00         .        8.00        .          .
  210        .         .          .           .         .           .         .          .          .          .          .
  211        1         .          .           .         .           .         .          .          .          .          .
  212        4        0.00        .           .         .           .         .          .          .          .          .
  217        2        0.03       0.03     3520.00     20.00     4338.00     83.00      28.00      7.00     2751.00     15.00
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                                         WASTE STREAM
                             DATA LISTING - SUBCATEGORIZATION FILE

---------------------------------------------- SUBCAT=PLASTICS ONLY ----------------------------------------------

PLANT          FLOWINF   FLOWEFF    BODINF    BODEFF    CODINF    CODEFF    TSSINF    TSSEFF    TOCINF    TOCEFF
NUMHER  # PP     (MGD)     (MGD)     (PPM)     (PPM)     (PPM)     (PPM)     (PPM)     (PPM)     (PPM)     (PPM)
-----  -----    ------    ------    ------    ------    ------    ------    ------    ------    ------    ------

 221      1        .         .         .         .         .         .         .         .         .         .  
 221      .       0.00       .         .         .         .         .         .         .         .         .  
 223      1       0.74      0.74       .       15.00       .         .         .       16.00       .         .  
 224      2       0.07      0.07    400.00     32.00    520.00     64.00   2078.00     64.00       .         .  
 225      1       0.17      0.17       .         .         .         .         .         .         .         .  
 227      1       0.09       .      478.00       .     1422.00       .         .         .         .         .  
 229      .       1.17      1.17    204.00      6.00    405.00     77.00     74.00     18.00       .         .  
 232      5        .         .         .         .         .         .         .         .         .         .  
 233      2       0.60      0.60     61.00     36.00    109.00     75.00       .         .      100.00     71.00
 237      1       0.70      0.70       .         .         .         .         .         .         .         .  
 240      3       0.00       .         .         .         .         .         .         .         .         .  
 241      1       0.10      0.10       .         .         .         .         .         .         .         .  
 242      1        .         .         .         .         .         .         .         .         .         .  
 243      1       0.00       .         .         .         .         .         .         .         .         .  
 244      1        .         .         .         .         .         .         .         .         .         .  
 244      .        .         .         .         .         .         .         .         .         .         .  
 246      3       0.48      0.48    572.00     99.00   1219.00    455.00     97.00     90.00       .         .  
 249      1       0.03      0.04       .        4.00       .       18.00       .        8.00       .         .  
 250      1       0.03      0.03       .         .         .         .        5.00      5.00       .         .  
 251      1        .         .         .         .         .         .         .         .         .         .  
 253      1        .         .         .         .         .         .         .         .         .         .  
 254      4       0.88      0.88    119.00     14.00    531.00     85.00    643.00     19.00       .         .  
 262      3       0.31      0.31    808.00     58.00   3080.00    323.00   2713.00    179.00       .         .  
 265      2       0.00       .         .         .         .         .         .         .         .         .  
 273      3       3.98      3.98    470.00     34.00    900.00    353.00     69.00     97.00       .         .  
 277      3       2.47      2.30    291.00     16.00   1893.00     94.00    407.00     45.00       .         .  
 280      2       0.00       .         .         .         .         .         .         .         .         .  
 282      3        .         .         .         .         .         .         .         .         .         .  
 287      3       1.50      1.50       .        7.00       .         .         .        6.00       .         .  
 288      2       0.50       .         .         .         .         .         .         .         .         .  
 288      1        .         .         .         .         .         .         .         .         .         .  
 289      4        .         .         .         .         .         .         .         .         .         .  
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                                                   WASTE STREAM                                                              5
                                        DATA LISTING - SUBCATEGORIZATION FILE

-------------------------------------- SUBCAT=NOT P, TYPE I&C, WATERUSE >.165 GAL/LB -----------------------------------------

 PLANT              FLOWINF    FLOWEFF    BODINF     BODEFF     CODINF     CODEFF     TSSINF     TSSEFF     TOCINF     TOCEFF
 NUMBER    # PP     (MGD)      (MGD)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)
 -----     -----    ------     ------     ------     ------     ------     ------     ------     ------     ------     ------

   20        3        0.72       0.72    2113.00     190.00    5370.00     725.00        .          .          .          .
   20        .         .          .         .          .          .          .          .          .          .          .
   31       11        1.10       1.10     997.00      22.00    2404.00     294.00      62.00      71.00        .          .
   36        6        0.06       0.06    2527.00     393.00    5629.00    2448.00    1946.00     148.00        .          .
   41        3         .          .         .          .          .          .          .          .          .          .
   41        .         .          .         .          .          .          .          .          .          .          .
   43        3         .          .         .          .          .          .          .          .          .          .
   43        .         .          .         .          .          .          .          .          .          .          .
   49       13        0.99        .         .          .      27632.00        .       459.00        .      11006.00        .
   51        .         .          .         .          .          .          .          .          .          .          .
   55       11        0.90        .      6022.00        .      10037.00        .          .          .      3613.00        .
   57        5        3.11       3.10    1385.00      38.00    1488.00     201.00        .       118.00        .          .
   60        4        5.03       5.07     501.00      41.00        .          .          .        88.00     469.00     159.00
   61       11        2.43       2.43     382.00      81.00     862.00     189.00        .          .       268.00     135.00
   62        5        2.13       1.35     199.00      68.00        .          .        27.00      20.00        .          .
   74       14        2.34       2.34       .          .          .          .          .          .       473.00      23.00
   74        .         .          .         .          .          .          .          .          .          .          .
   74        .         .          .         .          .          .          .          .          .          .          .
   76       51       18.36      15.80     582.00      15.00    1327.00     162.00      23.00      36.00     332.00      64.00
   80       25       29.70      29.00     153.00      10.00        .          .          .         9.00        .          .
   84        4        0.55       0.55       .          .          .          .          .          .          .          .
   84        4        0.27       0.27       .          .          .          .          .          .          .          .
   84        2         .          .         .          .          .          .          .          .          .          .
   84       13        6.67       6.66     279.00      54.00        .          .          .          .          .          .
   84        4        0.27       0.27       .          .          .          .          .          .          .          .
   88       26        1.33       1.33    1407.00      64.00    2454.00        .          .       142.00    1205.00     118.00
   95        1         .          .         .          .          .          .          .          .          .          .
   98       21        2.11       2.00     793.00      53.00     562.00     351.00        .        50.00        .          .
   98        .         .          .         .          .          .          .          .          .          .          .
   98        .         .          .         .          .          .          .          .          .          .          .
   99        2         .          .         .          .          .          .          .          .          .          .
  102        5        2.75       2.75     850.00      15.00        .          .          .        39.00     505.00      34.00
  103       14       12.20      12.20     319.00      19.00      53.00      28.00        .          .       128.00      28.00
  108       11        2.80        .         .          .          .          .          .          .          .          .
  110        3        2.04       2.04    1506.00       6.00    2883.00      55.00      57.00      13.00        .          .
  112        5        0.82       0.82    1177.00      53.00        .          .        72.00      26.00     685.00      69.00
  113       41       17.06      16.70    1719.00      28.00        .          .        36.00      21.00     793.00      61.00
  114       45        3.92       4.80     823.00      13.00        .       135.00      73.00      62.00     513.00      61.00
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                                          WASTE STREAM
                              DATA LISTING - SUBCATEGORIZATION FILE

---------------------------------------- SUBCAT=NOT P, TYPE I&C, WATERUSE >.165 GAL/LB ----------------------------------------

  PLANT             FLOWINF   FLOWEFF    BODINF    BODEFF    CODINF    CODEFF    TSSINF    TSSEFF    TOCINF    TOCEFF
  NUMBER    # PP    (MGD)     (MGD)      (PPM)     (PPM)     (PPM)     (PPM)     (PPM)     (PPM)     (PPM)     (PPM)
  -----    -----   ------    ------     ------    ------    ------    ------    ------    ------    ------    ------

   127      17      1.13      1.13      684.00    127.00    653.00    535.00     43.00     46.00       .      198.00
   134       3       .         .           .         .         .         .         .         .         .         .
   134       .       .         .           .         .         .         .         .         .         .         .
   135       3       .         .           .         .         .         .         .         .         .         .
   135       .       .         .           .         .         .         .         .         .         .         .
   136       5       .         .           .         .         .         .         .         .         .         .
   136       .       .         .           .         .         .         .         .         .         .         .
   137       3       .         .           .         .         .         .         .         .         .         .
   137       .       .         .           .         .         .         .         .         .         .         .
   139       5       .         .           .         .         .         .         .         .         .         .
   139       .       .         .           .         .         .         .         .         .         .         .
   141       3       .         .           .         .         .         .         .         .         .         .
   141       .       .         .           .         .         .         .         .         .         .         .
   142       3       .         .           .         .         .         .         .         .         .         .
   142       .       .         .           .         .         .         .         .         .         .         .
   143       5       .         .           .         .         .         .         .         .         .         .
   143       .       .         .           .         .         .         .         .         .         .         .
   158       6      0.40      0.37         .       61.00   4329.00    590.00       .       68.00       .         .
   160       5      0.55      0.49     5710.00     85.00   6757.00    220.00     28.00    104.00       .         .
   175       9      0.89      0.89      443.00     40.00    993.00    322.00       .         .         .         .
   176       7      1.07      1.07     2507.00     40.00       .         .      860.00    189.00       .         .
   180       7      3.00        .     14988.00       .    23744.00       .         .         .     8086.00       .
   180       .       .         .           .         .         .         .         .         .         .         .
   187       2      1.66      1.66     2629.00    127.00   4016.00    523.00       .      170.00       .         .
   190       .      0.26      0.26         .         .         .         .        9.00      9.00     23.00     23.00
   193      13      0.30      0.30      537.00    537.00   1577.00   1577.00      9.00      9.00       .         .
   195      16      6.50      6.50      559.00     24.00       .         .       98.00     42.00    336.00    100.00
   206       9      4.47      4.47         .       41.00       .      334.00       .       53.00       .         .
   215       1       .         .           .         .         .         .         .         .         .         .
   216       6      0.09      0.09     2400.00     19.00       .         .         .       29.00       .         .
   216       .       .         .           .         .         .         .         .         .         .         .
   220       3      0.09      0.09     3741.00     50.00   6178.00    368.00    344.00     95.00       .         .
   222       7      0.48      0.33      803.00    368.00   2976.00    654.00       .       16.00       .         .
   228      29      3.75      3.75         .       63.00       .      364.00       .       78.00   3112.00       .
   234      33      7.95      7.91      546.00     12.00   1354.00    199.00       .         .         .         .
   235       8      5.10      5.10         .       89.00   2605.00    367.00    428.00    235.00    719.00       .
   236      18      4.08      4.08         .       37.00       .      193.00       .       65.00    334.00     53.00
   236       .       .         .           .         .         .         .         .         .         .         .
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                                              WASTE STREAM
                                  DATA LISTING - SUBCATEGORIZATION FILE
---------------------------------------- SUBCAT=NOT P, TYPE I&C, WATERUSE >.165 GAL/LB -----------------------------------------

PLANT             FLOWINF  FLOWEFF  BODINF   BODEFF   CODINF   CODEFF   TSSINF   TSSEFF   TOCINF   TOCEFF
NUMBER    # PP    (MGD)    (MGD)    (PPM)    (PPM)    (PPM)    (PPM)    (PPM)    (PPM)    (PPM)    (PPM)
-----     -----   ------   ------   ------   ------   ------   ------   ------   ------   ------   ------

 238        3       .        .        .        .        .        .        .        .        .        .
 248        2     2.01     1.60   4490.00    72.00  8334.00   217.00    86.00    74.00  3202.00    73.00
 249        5     0.68     0.68       .      12.00  5141.00   120.00      .      19.00       .        .
 257        6     0.62     0.62   1211.00   103.00      .        .        .      66.00       .        .
 260        8     0.27       .        .        .        .        .        .        .        .        .
 272       15     3.99     4.25    970.00    22.00  2189.00   147.00      .      86.00   695.00    74.00
 274       39     9.33       .     450.00      .    1122.00      .     103.00      .     282.00      .
 276        6     0.95     0.95       .        .        .     256.00      .     132.00       .        .
```

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                                          WASTE STREAM
                              DATA LISTING - SUBCATEGORIZATION FILE                                                  8

---------------------------------- SUBCAT=NOT P, TYPE I&C, WATERUSE<=.165 GAL/LB ----------------------------------------

 PLANT             FLOWINF   FLOWEFF     BODINF     BODEFF     CODINF     CODEFF     TSSINF     TSSErF     TOCINF     TOCEFF
 NUMBER    # PP    (MGD)     (MGD)       (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)      (PPM)
 ------   -----    ------    ------      ------     ------     ------     ------     ------     ------     ------     ------

   37        4      0.02        .           .          .          .          .          .          .          .          .
   38        8      1.30        .        670.00        .       960.00        .        61.00        .          .          .
   40        5      0.01      0.01          .          .          .          .          .          .          .          .
   42        3      0.05      0.05      5961.00     380.00    3683.00     541.00        .          .          .          .
   49        .      1.01      1.01          .         7.00        .          .          .        34.00      20.00      15.00
   50       21      0.38      0.25      3913.00      33.00        .       278.00        .        74.00        .          .
   50        .      0.12        .           .          .          .          .          .          .          .          .
   51       10      0.68        .           .          .          .          .          .          .          .          .
   51        .      0.07        .           .          .          .          .          .          .          .          .
   63        .      0.01        .           .          .          .          .          .          .          .          .
   63       10      0.56      0.56       891.00     468.00    5496.00    4079.00        .       194.00    1079.00     685.00
   63        .      6.74      6.74        43.00      43.00     271.00     271.00      12.00      12.00        .          .
   63        .      0.27        .           .          .          .          .          .          .          .          .
   81        2      0.12      0.11          .       104.00        .          .          .          .      1199.00     417.00
   81        3      0.26      0.30          .       288.00        .          .          .       140.00        .       360.00
   81        1      0.00        .           .          .          .          .          .          .          .          .
   84        4      0.12      0.12          .          .          .          .          .          .          .          .
  138       10      0.49      0.49          .       251.00    3091.00     583.00        .       250.00        .          .
  160        .      0.05        .       52554.00       .      67095.00       .          .          .          .          .
  163        5      0.03      0.03      3977.00     154.00    8237.00     638.00        .          .          .          .
  177       31      2.22      2.22       288.00      16.00        .          .          .          .          .          .
  177        .      0.26        .           .          .     20000.00       .          .          .          .          .
  177        .      1.23        .           .          .     25000.00       .          .          .          .          .
  188       20      1.00      1.00      1076.00      36.00    9229.00     240.00    4110.00      45.00        .          .
  193        .      0.01        .       21425.00       .      62383.00       .          .          .          .          .
  218        2      0.02      0.02          .       111.00   11360.00    1178.00     665.00     395.00        .          .
  219        3      0.05      0.05      2514.00      30.00    3514.00     545.00        .       105.00        .          .
  239        3      0.01      0.01          .         9.00        .        60.00        .        37.00        .          .
  267        9      0.35        .       5618.00        .          .          .          .          .          .          .
  268       26      2.50      2.50      4847.00     248.00    8060.00    1069.00        .          .          .          .
  271       18      1.72      1.12      3015.00      39.00    5842.00     222.00        .       150.00    1475.00      65.00
  276        .      0.11        .           .          .          .          .          .          .          .          .
  279        3      0.01      0.01          .          .     21178.00     249.00     285.00     111.00        .          .
```

WASTE STREAM
DATA LISTING - SUBCATEGORIZATION FILE

SUBCAT=NOT P, TYPE I=NOT C

PLANT NUMBER	# PP	FLOWINF (MGD)	FLOWEFF (MGD)	BODINF (PFM)	BODEFF (PPM)	CODINF (PPM)	CODEFF (P?M)	TSSINF (PPM)	TSSEFF (PPM)	TOCINF (PPM)	TOCEFF (PPM)
1	9	0.88	0.66	1137.00	47.00	2073.00	354.00	494.00	62.00	.	.
15	9	2.44	2.44	809.00	23.00	1822.00	380.00	.	.	.	.
16	6	4.60	4.60	.	632.00	.	523.00	.	804.00	.	276.00
16	2	0.84	.	.	.	.	.	93.00	.	.	.
22	11	2.49	2.49	.	.	.	.	.	18.00	175.00	36.00
22	.	0.22	.	781.00	.	1810.00	.	.	.	364.00	.
26	6	4.03	.	.	.	.	.	.	.	.	.
28	4	3.57	3.57	279.00	31.00	210.00	63.00	30.00	13.00	.	.
32	9	0.02	0.03	647.00	80.00	5546.00	.	2686.00	36.00	2056.00	.
35	3	0.08	0.08	9.00	9.00	28.00	28.00	1.00	1.00	.	.
53	3	2.28	2.28	1201.00	28.00	.	117.00	.	74.00	.	.
64	3	0.86	0.86	655.00	13.00	854.00	30.00	991.00	13.00	.	.
69	3	.	.	.	.	.	.	.	.	.	.
83	17	.	.	.	.	.	.	.	.	.	.
85	4	0.31	0.30	.	30.00	.	818.00	.	67.00	.	.
87	8	0.84	0.84	.	.	.	.	.	.	431.00	42.00
87	.	0.05	.	.	.	.	.	.	.	.	141.00
87	.	.	.	.	.	.	.	.	.	.	.
117	11	3.60	3.60	.	11.00	120.00	40.00	.	13.00	.	14.00
118	16	7.16	7.16	467.00	13.00	.	.	.	.	.	.
128	5	3.38	3.38	200.00	26.00	300.00	105.00	58.00	38.00	75.00	26.00
128	.	.	.	.	.	.	.	.	.	.	.
130	8	32.05	32.10	62.00	17.00	.	.	.	8.00	.	.
149	15	0.30	.	3044.00	.	11966.00	.	33.00	.	.	.
159	1	0.64	0.64	.	16.00	.	.	.	22.00	.	.
162	3	0.08	.	42.00	.	14.00	.	.	.	.	.
164	12	0.36	0.36	2436.00	82.00	3449.00	335.00	177.00	106.00	.	98.00
165	15	0.00	.	.	.	.	.	.	.	.	.
170	22	2.90	2.90	349.00	28.00	.	.	.	.	.	.
171	16	1.44	1.44	.	26.00	.	.	.	48.00	272.00	60.00
178	7	2.80	2.76	1327.00	168.00	3067.00	713.00	.	78.00	971.00	501.00
183	11	3.10	3.32	78.00	9.00	.	.	.	19.00	66.00	19.00
183	2	0.38	.	.	.	.	.	32.00	.	130.00	.
184	11	0.22	0.22	.	12.00	.	.	.	46.00	.	.
191	6	0.00	.	.	.	.	.	.	.	.	.
201	5	0.02	0.02	2668.00	780.00	32476.00	11000.00	780.00	851.00	.	.
203	4	0.11	0.11	2725.00	181.00	7957.00	1697.00	164.00	147.00	.	.
204	24	0.16	0.16	.	25.00	.	99.00	.	.	.	35.00

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                                                  WASTE STREAM
                                      DATA LISTING - SUBCATEGORIZATION FILE

-------------------------------------------------- SUBCAT=NOT P, TYPE I&NOT C --------------------------------------------------

 PLANT              FLOWINF   FLOWEFF   BODINF    BODEFF    CODINF     CODEFF    TSSINF    TSSEFF    TOCINF    TOCEFF
 NUMBER    # PP     (MGD)     (MGD)     (PPM)     (PPM)     (PPM)      (PPM)     (PPM)     (PPM)     (PPM)     (PPM)
 -----     -----    ------    ------    ------    ------    ------     ------    ------    ------    ------    ------

  213        3       0.00       .         .         .          .          .         .         .         .         .
  213        3        .         .         .         .          .          .         .         .         .         .
  230        3       0.42      0.32    129.00    115.00     423.00     385.00    170.00     13.00    143.00    118.00
  230        8       0.34       .      209.00       .       612.00        .      267.00       .      175.00       .
  256        4       0.17      0.17       .       20.00        .       100.00       .       38.00       .         .
  256        .       0.00       .         .         .          .          .         .         .         .         .
  259       12       0.03      0.03       .       13.00        .        75.00       .         .         .       24.00
  263       18       0.01      0.03       .       37.00   13080.00     226.00       .       31.00   5226.00    132.00
  264        6       1.80      1.80    266.00     17.00     333.00      40.00    133.00     27.00     67.00      7.00
  266        5       0.40       .         .         .          .          .         .         .         .         .
  269       20       4.31      4.31    830.00     66.00        .          .      472.00     71.00    867.00    176.00
  275       11       0.14      0.14    116.00    116.00        .          .       80.00     80.00       .         .
  281       12       1.00      1.00     66.00     11.00        .          .         .         .         .         .
  283        4        .         .         .         .          .          .         .         .         .         .
  284        9       0.33      0.33       .         .          .      2960.00       .       18.00       .         .
  286        6       0.00       .         .         .          .          .         .         .         .         .
  286        3        .         .         .         .          .          .         .         .         .         .
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                                                   WASTE STREAM
                                       DATA LISTING - SUBCATEGORIZATION FILE

----------------------------------------------------- SUBCATWNOT P, NOT TYPE I -----------------------------------------------------

 PLANT             FLOWINF  FLOWEFF  BODINF   BODEFF   CODINF    COUEFF   TSSINF   TSSEFF   TOCINF   TOCEFF
 NUMBER   # PP     (MGD)    (MGD)    (PPM)    (PPM)    (PPM)     (PPM)    (PPM)    (PPM)    (PPM)    (PPM)
 -----    -----    ------   ------   ------   ------   ------    ------   ------   ------   ------   ------

   5        5       0.37     0.37       .         .        .       43.00      .       7.00      .      17.00
   6        1       0.01     0.01       .      279.00      .     1045.00      .         .       .        .
   8        2       0.08     0.08       .      104.00      .      241.00      .      37.00      .        .
   8        .         .        .        .         .        .         .        .         .       .        .
   8        1       0.14     0.14       .       17.00      .       22.00      .      19.00      .        .
  18        3       4.39     4.39    330.00     10.00    590.00     65.00    17.00    29.00      .        .
  21        5       4.09     4.09       .       12.00      .       40.00      .       2.00      .        .
  23        3       0.54       .        .         .        .         .        .         .       .        .
  24        4       0.43     0.43       .         .        .         .        .         .    502.00   133.00
  59        7       1.46     1.46    520.00     24.00   5488.00    110.00      .      24.00      .        .
  66        2       1.35     1.40       .       12.00      .       75.00      .     442.00      .      21.00
  71        4         .        .        .         .        .         .        .         .       .        .
  72        8       1.43     1.43       .         .      218.00    111.00      .         .       .        .
  86        8       1.28     1.28       .       50.00      .         .        .      13.00      .        .
  92        5       4.38     4.38       .        4.00      .       39.00      .      10.00      .       9.00
  92        .       0.04       .        .         .        .         .        .         .       .        .
  94       22      40.00    40.00    180.00      8.00      .         .     111.00   101.00   194.00      .
  97        2       0.86     0.86    429.00     14.00    694.00    278.00   121.00    78.00      .        .
 101       10       7.50     7.50       .         .        .         .        .         .       .        .
 101       10       0.13       .        .         .        .         .        .         .       .        .
 115       13       0.74       .        .         .        .         .        .         .       .        .
 116       14      13.90    13.90       .         .        .         .     138.00    15.00    35.00    16.00
 120       14      19.16    19.90     95.00      8.00    266.00     89.00    34.00    32.00    68.00    34.00
 121        4       0.09     0.09       .        8.00    286.00     68.00    19.00    18.00    92.00      .
 121        .         .        .        .         .        .         .        .         .       .        .
 122        3       2.00     2.00       .       27.00      .        8.00      .      51.00      .       6.00
 129        .         .        .        .         .        .         .        .         .       .        .
 131        .       0.00       .        .         .        .         .        .         .       .        .
 133        6         .        .        .         .        .         .        .         .       .        .
 144        5       0.95     0.95       .       27.00    744.00    413.00  1266.00    34.00      .        .
 145        6       1.57     1.57       .       42.00      .      252.00      .      37.00      .      48.00
 151        2       3.00     3.00       .       22.00      .      102.00      .      18.00      .      41.00
 151        4         .        .        .         .        .         .        .         .       .        .
 153        3       0.33     0.33       .      122.00      .      162.00      .      42.00      .      62.00
 166        1       0.01       .        .         .        .         .        .         .       .        .
 169        5       0.01       .        .         .        .         .        .         .       .        .
 172        6       2.60       .     261.00       .     1384.00       .     106.00       .       .        .
 181        6       0.01       .    1439.00       .    17186.00       .    7554.00       .   9592.00      .
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WASTE STREAM
DATA LISTING - SUBCATEGORIZATION FILE

-- SUBCAT=NOT P, NOT TYPE I --

PLANT NUMBER	# PP	FLOWINF (MGD)	FLOWEFF (MGD)	BODINF (PPM)	BODEFF (PPM)	CODINF (PPM)	CODEFF (PPM)	TSSINF (PPM)	TSSEFF (PPM)	TOCINF (PPM)	TOCEFF (PPM)
181	1	.	.	.	.	.	.	.	.	.	.
182	1	0.53	0.55	238.00	36.00	.	.	85.00	26.00	492.00	61.00
186	5	0.32	0.33	162.00	5.00	5224.00	146.00	670.00	20.00	.	.
205	3	0.00	0.01	.	14.00	.	159.00	.	154.00	.	.
208	11	0.54	0.45	318.00	27.00	456.00	139.00	.	41.00	175.00	.
214	7	.	.	.	.	.	.	.	.	.	.
226	10	1.36	1.20	481.00	23.00	1979.00	250.00	1225.00	55.00	.	.
231	2	0.15	0.16	1743.00	772.00	4556.00	1326.00	847.00	21.00	1455.00	315.00
245	15	.	0.28	.	12.00	.	.	1198.00	18.00	.	15.00
247	10	3.10	3.10	.	3.00	260.00	69.00	.	26.00	.	.
252	10	0.11	.	.	.	2956.00	.	.	.	.	.
252	.	0.24	.	.	.	.	.	.	.	.	.
252	1	0.67	.	.	.	27872.00	.	33178.00	.	.	.
255	8	0.40	0.40	.	.	.	31.00	.	16.00	.	.
258	5	0.01	0.01	.	51.00	.	243.00	.	37.00	.	70.00
261	2	0.10	0.10	.	.	.	.	.	.	.	.
270	4	0.97	0.95	143.00	17.00	345.00	51.00	204.00	12.00	.	.
278	8	.	.	.	.	.	.	.	.	.	.
285	9	1.80	.	.	.	.	.	.	.	.	.
290	3	0.10	.	193.00	.	546.00	.	81.00	.	161.00	.
291	1	.	.	.	.	.	.	.	.	.	.

WASTE STREAM
DATA LISTING - SUBCATEGORIZATION FILE

-- SUBCAT=PLASTICS ONLY --

PLANT NUMBER	ORGANIC PP	PLASTIC PP	OTHER	WTF	DISCHARGE
2	0	2	0	SSK	DIR
3	0	2	0	ASL	DIR
4	0	2	1	DP*	ZERO
7	0	2	0	LAP	ZERO
9	0	2	0	ASL	DIR
10	0	3	0	ALA	DIR
11	0	1	0	BRN	ZERO
11	0	0	0	CLR	DIR
12	0	1	0	BRN	ZERO
13	0	2	0	RTE	ZERO
14	0	3	0	CON	ZERO
17	0	3	0	RBC	DIR
17	0	0	0	CON	ZERO
19	0	5	3	ASL	DIR
25	0	1	0	CLR	DIR
27	0	3	2	ASL	DIR
29	0	1	1	ASL	DIR
30	0	2	1	CON	ZERO
33	0	1	0	PCF	DIR
34	0	1	0	ASL	DIR
35	0	1	0	BRN	ZERO
39	0	4	0	ASL	DIR
44	0	1	0	ASL	DIR
45	0	2	0	ASL	DIR
46	0	2	0	RTE	ZERO
47	0	5	0	BRN	ZERO
47	0	0	0	CON	ZERO
48	0	1	0	RTE	ZERO
52	0	2	0	ASL	DIR
54	0	1	0	RBC	DIR
56	0	1	0	IMP	ZERO
58	0	1	0	RTE	ZERO
62	0	1	0	IMP	ZERO
65	0	2	1	ASL	DIR
67	0	1	0	DRY	ZERO
68	0	2	0	DRY	ZERO
70	0	2	0	DRY	ZERO
73	0	2	1	ASL	DIR

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                                        WASTE STREAM
                            DATA LISTING - SUBCATEGORIZATION FILE

----------------------------------------------------- SUBCAT=PLASTICS ONLY -----------------------------------------------------

                     PLANT     ORGANIC     PLASTIC
                     NUMBER    PP          PP          OTHER    WTF     DISCHARGE
                     -----     -------     -------     -----    -----   ---------

                       75        0           2           0       TRF      DIR
                       77        0           4           0       NOT      DIR
                       77        0           0           0       IMP      ZERO
                       77        0           0           0       OLS      DIR
                       78        0           1           0       EVP      ZERO
                       79        0           2           0       DPW      ZERO
                       82        0           3           0       BRN      ZERO
                       82        0           3           0       DRY      ZERO
                       84        0           1           0       CLR      DIR
                       84        0           1           0       OLS      DIR
                       89        0           4           0       ASL      DIR
                       90        0           2           0       RBC      DIR
                       91        0           2           0       ASL      DIR
                       91        0           0           0       IMP      ZERO
                       93        0           1           0       ASL      DIR
                       96        0           1           0       ASL      DIR
                      100        0           2           0       ASL      DIR
                      100        0           0           0       ARL      DIR
                      104        0           7           0       ASL      DIR
                      104        0           0           0       DPW      ZERO
                      104        0           0           0       IMP      ZERO
                      104        0           0           0       NEU      DIR
                      105        0           1           0       ASL      DIR
                      106        0           5           1       ALA      DIR
                      107        0           1           0       ASL      DIR
                      109        0           3           0       ASL      DIR
                      111        0           1           0       ASL      DIR
                      119        0           1           0       OLS      DIR
                      123        0           1           1       ASL      DIR
                      124        0           2           0       ASL      DIR
                      125        0           2           0       ASL      DIR
                      126        0           3           0       ASL      DIR
                      129        0           3           0       CON      ZERO
                      131        0           1           0       CON      ZERO
                      132        0           1           0       ALA      DIR
                      140        0           2           0       DRY      ZERO
                      140        0           0           0       RTE      ZERO
                      146        0           4           1       ASL      DIR
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                                        WASTE STREAM
                          DATA LISTING - SUBCATEGORIZATION FILE

------------------------------------------------- SUBCAT=PLASTICS ONLY -------------------------------------------------

                     PLANT     ORGANIC     PLASTIC
                     NUMBER    PP          PP          OTHER    WTF      DISCHARGE
                     -----     -------     -------     -----    -----    ---------

                      147        0           2           1       ASL       DIR
                      148        0           1           0       DRY       ZERO
                      150        0           3           3       ALA       DIR
                      152        0           1           0       CLR       DIR
                      152        0           1           0       CLR       DIR
                      154        0           2           1       CON       ZERO
                      155        0           4           2       DRY       ZERO
                      155        0           0           0       RTE       ZERO
                      155        0           0           0       CON       ZERO
                      156        0           2           0       SSK       DIR
                      157        0           1           0       ASL       DIR
                      161        0           2           0       DRY       ZERO
                      167        0           1           0       CON       ZERO
                      168        0           1           0       UNK       UNK
                      173        0           4           1       CON       ZERO
                      174        0           4           3       ASL       DIR
                      179        0           2           1       ASL       DIR
                      184        0           4           0       SSK       DIR
                      185        0           1           0       CON       ZERO
                      189        0           1           0       ALA       DIR
                      192        0           2           1       ASL       DIR
                      194        0           1           1       NOT       DIR
                      196        0           1           0       CLR       DIR
                      197        0           3           0       RTE       ZERO
                      197        0           1           0       BRN       ZERO
                      198        0           1           0       DRY       ZERO
                      199        0           3           0       RTE       ZERO
                      199        0           1           0       RTE       ZERO
                      200        0           1           0       BRN       ZERO
                      200        0           0           0       IMP       ZERO
                      202        0           1           0       ARL       DIR
                      207        0           2           0       DRY       ZERO
                      209        0           1           0       BRN       ZERO
                      210        0           8           0       ASL       DIR
                      210        0           0           0       BRN       ZERO
                      211        0           1           0       LAP       ZERO
                      212        0           4           0       LAP       ZERO
                      217        0           2           0       ASL       DIR
```

WASTE STREAM
DATA LISTING - SUBCATEGORIZATION FILE

SUBCAT=PLASTICS ONLY

PLANT NUMBER	ORGANIC PP	PLASTIC PP	OTHER	WTF	DISCHARGE
221	0	1	0	DRY	ZERO
221	0	0	0	CON	ZERO
223	0	1	0	ALA	DIR
224	0	2	0	ASL	DIR
225	0	1	0	ALA	DIR
227	0	1	0	OFS	ZERO
229	0	5	1	ASL	DIR
232	0	5	0	NOT	DIR
233	0	2	0	RBC	DIR
237	0	1	0	ASL	DIR
240	0	2	1	EVP	ZERO
241	0	1	0	OLS	DIR
242	0	1	0	CON	ZERO
243	0	1	0	CON	ZERO
244	0	1	0	DRY	ZERO
244	0	0	0	IMP	ZERO
246	0	3	0	CLR	DIR
249	0	1	0	OLS	DIR
250	0	1	0	NOT	DIR
251	0	1	0	DRY	ZERO
253	0	1	0	BRN	ZERO
254	0	5	0	ALA	DIR
262	0	3	0	ASL	DIR
265	0	2	0	CON	ZERO
273	0	3	0	ASL	DIR
277	0	3	0	ASL	DIR
280	0	2	0	RTE	ZERO
282	0	2	0	UNK	UNK
287	0	3	0	ARL	DIR
288	0	2	0	CON	ZERO
288	0	0	1	DRY	ZERO
289	0	3	1	DRY	ZERO

```
                                          WASTE STREAM                                                   17
                                DATA LISTING - SUBCATEGORIZATION FILE

------------------------------------------ SUBCATNOT P, TYPE I&C, WATERUSE >,165 GAL/LB ------------------------------------------

                        PLANT     ORGANIC     PLASTIC
                        NUMBER    PP          PP          OTHER    WTF      DISCHARGE
                        -----     -------     -------     -----    -----    ---------

                          20         1           2          0       ASL        DIR
                          20         0           0          0       BRN        ZERO
                          31         8           0          3       ASL        DIR
                          36         1           5          0       ASL        DIR
                          41         1           2          0       DRY        ZERO
                          41         0           0          0       IMP        ZERO
                          43         1           2          0       DRY        ZERO
                          43         0           0          0       IMP        ZERO
                          49        11           0          2       DPW        ZERO
                          51         0           0          0       DRY        ZERO
                          55        11           0          0       IMP        ZERO
                          57         3           2          0       ASL        DIR
                          60         3           1          0       ASL        DIR
                          61         9           2          0       ASL        DIR
                          62         1           3          0       ALA        DIR
                          74        12           1          1       ASL        DIR
                          74         0           0          0       BRN        ZERO
                          74         0           0          0       DPW        ZERO
                          76        44           7          1       ALA        DIR
                          80        15           5          5       ASL        DIR
                          84         4           0          0       OLS        DIR
                          84         5           0          0       NOT        DIR
                          84         2           0          0       UNK        UNK
                          84        11           1          0       ASL        DIR
                          84         4           0          0       NOT        DIR
                          88        23           0          3       ASL        DIR
                          95         1           0          0       BRN        ZERO
                          98        11           0          8       ASL        DIR
                          98         1           1          0       DPW        ZERO
                          98         0           0          0       BRN        ZERO
                          99         1           0          1       BRN        ZERO
                         102         2           2          1       ASL        DIR
                         103         8           3          3       ANL        DIR
                         108         5           2          4       DPW        ZERO
                         110         2           1          0       ASL        DIR
                         112         2           2          1       ASL        DIR
                         113        29          12          0       ASL        DIR
                         114        39           5          1       ALA        DIR
```

```
                                              WASTE STREAM                                                        18
                                DATA LISTING - SUBCATEGORIZATION FILE

--------------------------------------- SUBCATENOT P, TYPE I&C, WATERUSE >,165 GAL/LB ----------------------------------------

                     PLANT     ORGANIC     PLASTIC
                     NUMBER    PP          PP          OTHER    WTF     DISCHARGE
                     -----     -------     -------     -----    -----   ---------

                      127        14           4          0       ASL      DIR
                      134         1           2          0       DRY      ZERO
                      134         0           0          0       RTE      ZERO
                      135         1           2          0       DRY      ZERO
                      135         0           0          0       RTE      ZERO
                      136         2           2          1       DRY      ZERO
                      136         0           0          0       RTE      ZERO
                      137         1           2          0       DRY      ZERO
                      137         0           0          0       RTE      ZERO
                      139         2           2          1       DRY      ZERO
                      139         0           0          0       RTE      ZERO
                      141         1           2          0       DRY      ZERO
                      141         0           0          0       RTE      ZERO
                      142         1           2          0       DRY      ZERO
                      142         0           0          0       RTE      ZERO
                      143         2           2          1       DRY      ZERO
                      143         0           0          0       RTE      ZERO
                      158         4           0          2       ASL      DIR
                      160         4           1          0       ASL      DIR
                      175         2           6          1       ASL      DIR
                      176         6           0          1       ASL      DIR
                      180         3           2          2       DPW      ZERO
                      180         0           0          0       OLS      DIR
                      187         1           0          1       ASL      DIR
                      190         2           0          0       NOT      DIR
                      193         3           3          0       NOT      DIR
                      195        16           0          0       ASL      DIR
                      206         8           1          0       ALA      DIR
                      215         1           0          0       RTE      ZERO
                      216         1           5          0       ASL      DIR
                      216         0           0          0       BRN      ZERO
                      220         1           2          0       ASL      DIR
                      222         3           4          0       ACR      DIR
                      228        21           1          7       ASL      DIR
                      234        31           1          1       ASL      DIR
                      235         8           0          0       ASL      DIR
                      236        15           0          3       ASL      DIR
                      236         0           0          0       DPW      ZERO
```

```
                                        WASTE STREAM
                               DATA LISTING - SUBCATEGORIZATION FILE

------------------------------------- SUBCAT=NOT P, TYPE I&C, WATERUSE >.165 GAL/LB ------------------------------------------

                         PLANT    ORGANIC    PLASTIC
                         NUMBER   PP         PP         OTHER    WTF     DISCHARGE
                         -----    -------    -------    -----    -----   ---------

                          238         1          2        0      RTE       ZERO
                          248         2          0        0      ASL       DIR
                          249         5          0        0      ASL       DIR
                          257         4          2        0      ASL       DIR
                          260         3          0        2      OFS       ZERO
                          272        12          3        0      ANL       DIR
                          274        36          3        0      OFS       ZERO
                          276         5          1        0      ALA       DIR
```

```
                                          WASTE STREAM
                              DATA LISTING - SUBCATEGORIZATION FILE

------------------------------------ SUBCAT=NOT P, TYPE I&C, WATERUSE<=.165 GAL/LB ------------------------------------------

                 PLANT     ORGANIC     PLASTIC
                 NUMBER    PP          PP           OTHER     WTF      DISCHARGE
                 -----     -------     -------      -----     -----    ---------

                  37          2           2           0        RTE       ZERO
                  38          6           0           2        DPW       ZERO
                  40          1           3           1        MMF       DIR
                  42          1           2           0        ASL       DIR
                  49          0           0           0        ALA       DIR
                  50         18           3           0        ASL       DIR
                  50          0           0           0        IMP       ZERO
                  51         10           0           0        DPW       ZERO
                  51          0           0           0        BRN       ZERO
                  63          0           0           0        BRN       ZERO
                  63          6           0           4        ASL       DIR
                  63          0           0           0        NOT       DIR
                  63          0           0           0        DPW       ZERO
                  81          2           0           0        ASL       DIR
                  81          3           0           0        STR       DIR
                  81          1           0           0        BRN       ZERO
                  84          5           0           0        NOT       DIR
                 138          6           1           3        ALA       DIR
                 160          0           0           0        BRN       ZERO
                 163          5           0           0        ASL       DIR
                 177         29           2           0        ASL       DIR
                 177          0           0           0        DPW       ZERO
                 177          0           0           0        DPW       ZERO
                 188         15           2           3        ASL       DIR
                 193          1           2           0        BRN       ZERO
                 218          1           1           0        ALA       DIR
                 219          1           2           0        ASL       DIR
                 239          1           2           0        ASL       DIR
                 267          8           0           1        IMP       ZERO
                 268         26           0           0        ASL       DIR
                 271         15           3           0        ASL       DIR
                 276          0           0           0        DPW       ZERO
                 279          1           2           0        ALA       DIR
```

```
                                       WASTE STREAM
                          DATA LISTING - SUBCATEGORIZATION FILE
------------------------------------------------ SUBCAT=NOT P, TYPE I&NOT C ------------------------------------------------
                PLANT     ORGANIC     PLASTIC
                NUMBER    PP          PP          OTHER    WTF     DISCHARGE
                -----     -------     -------     -----    -----   ---------

                   1          2           6          1      ALA      DIR
                  15          1           8          0      ASL      DIR
                  16          3           1          2      PCF      DIR
                  16          1           0          1      DPW      ZERO
                  22          9           2          0      ASL      DIR
                  22          0           0          0      DPW      ZERO
                  26          6           0          0      RTE      ZERO
                  28          1           2          1      TRF      DIR
                  32          9           0          0      ALA      DIR
                  35          2           1          0      NOT      DIR
                  53          1           2          0      ASL      DIR
                  64          1           1          1      ALA      DIR
                  69          2           1          0      DRY      ZERO
                  83         11           1          5      RTE      ZERO
                  85          2           2          0      NEU      DIR
                  87          4           1          1      ASL      DIR
                  87          0           0          0      DPW      ZERO
                  87          2           0          0      ACR      DIR
                 117          8           0          2      ALA      DIR
                 118         14           1          1      OXY      DIR
                 128          2           2          1      OXY      DIR
                 128          0           0          0      DPW      ZERO
                 130          4           3          1      PCF      DIR
                 149         13           0          2      IMP      ZERO
                 159          1           0          0      NEU      DIR
                 162          3           0          0      IMP      ZERO
                 164         11           0          1      ASL      DIR
                 165          7           5          3      CON      ZERO
                 170         14           3          5      ASL      DIR
                 171          8           2          6      ASL      DIR
                 178          2           5          0      ASL      DIR
                 183          7           2          2      ARL      DIR
                 183          1           1          1      DPW      ZERO
                 184          1           0          0      ASL      DIR
                 191          5           1          0      BRN      ZERO
                 201          3           0          2      ASL      DIR
                 203          4           0          0      ASL      DIR
                 204         22           0          2      ACR      DIR
```

```
                                              WASTE STREAM
                                   DATA LISTING - SUBCATEGORIZATION FILE

---------------------------------------------- SUBCAT=NOT P, TYPE I&NOT C ----------------------------------------------

                    PLANT     ORGANIC    PLASTIC
                    NUMBER    PP         PP         OTHER    WTF     DISCHARGE
                    -----     -------    -------    -----    -----   ---------

                     213         1          2         0       CON      ZERO
                     213         0          3         0       DRY      ZERO
                     230         3          0         0       CLR      DIR
                     230         7          1         0       DPW      ZERO
                     256         1          3         0       BSK      DIR
                     256         0          0         0       IMP      ZERO
                     259        12          0         0       ACR      DIR
                     263        17          1         0       ASL      DIR
                     264         2          1         3       ASL      DIR
                     266         4          1         0       IMP      ZERO
                     269        15          2         3       ASL      DIR
                     275         5          6         0       NOT      DIR
                     281        11          0         1       ASL      DIR
                     283         3          1         0       DRY      ZERO
                     284         8          0         1       NEU      DIR
                     286         2          4         0       CON      ZERO
                     286         0          2         1       DRY      ZERO
```

```
                                                  WASTE STREAM
                                     DATA LISTING - SUBCATEGORIZATION FILE

-------------------------------------------------- SUBCAT=NOT P, NOT TYPE I --------------------------------------------------

                             PLANT     ORGANIC     PLASTIC
                             NUMBER    PP          PP          OTHER     WTF      DISCHARGE
                             -----     -------     -------     -----     -----    ---------

                                 5        1           1          3        CLR       DIR
                                 6        1           0          0        ALA       DIR
                                 8        2           0          0        OLS       DIR
                                 8        0           0          0        OFS       ZERO
                                 8        1           0          0        NEU       DIR
                                18        1           1          1        ASL       DIR
                                21        3           2          0        ALA       DIR
                                23        3           0          0        RTE       ZERO
                                24        1           3          0        ALA       DIR
                                59        4           3          0        ASL       DIR
                                66        2           0          0        NEU       DIR
                                71        3           0          1        DRY       ZERO
                                72        4           3          1        ASL       DIR
                                86        5           0          3        CLR       DIR
                                92        5           0          0        NEU       DIR
                                92        0           0          0        DPW       ZERO
                                94       19           1          2        ASL       DIR
                                97        1           1          0        ASL       DIR
                               101        6           3          1        NEU       DIR
                               101        0           0          0        DPW       ZERO
                               115        9           2          2        DPW       ZERO
                               116        9           2          3        ALA       DIR
                               120        8           3          3        ALA       DIR
                               121        4           0          0        ACR       DIR
                               121        0           0          0        DRY       ZERO
                               122        3           0          0        OLS       DIR
                               129        0           0          0        BRN       ZERO
                               131        0           0          0        IMP       ZERO
                               133        1           5          0        CON       ZERO
                               144        3           2          0        ASL       DIR
                               145        4           1          1        ARL       DIR
                               151        2           0          0        ASL       DIR
                               151        3           1          0        ALA       DIR
                               153        3           0          0        DAF       DIR
                               166        1           0          0        CON       ZERO
                               169        4           0          1        RTE       ZERO
                               172        6           0          0        CON       ZERO
                               181        1           3          1        IMP       ZERO
```

```
                                         WASTE STREAM
                          DATA LISTING - SUBCATEGORIZATION FILE

---------------------------------------------- SUBCAT=NOT P, NOT TYPE I ----------------------------------------------

              PLANT      ORGANIC     PLASTIC
              NUMBER     PP          PP          OTHER     WTF      DISCHARGE
              -----      -------     -------     -----     -----    ---------

               181          0           1          0        DRY       ZERO
               182          1           0          0        STR       DIR
               186          1           4          0        ASL       DIR
               205          2           0          1        NEU       DIR
               208         10           0          1        ASL       DIR
               214          1           3          3        DRY       ZERO
               226          1           8          1        TRF       DIR
               231          1           1          0        ACR       DIR
               245         14           0          1        STR       DIR
               247          5           4          1        ASL       DIR
               252          2           0          7        OFS       ZERO
               252          0           1          0        OFS       ZERO
               252          1           0          0        DPW       ZERO
               255          6           0          2        NEU       DIR
               258          5           0          0        ACR       DIR
               261          1           1          0        NOT       DIR
               270          1           3          0        OXY       DIR
               278          2           5          1        DRY       ZERO
               285          5           0          4        DPW       ZERO
               290          2           1          0        DPW       ZERO
               291          1           0          0        BRN       ZERO
```

```
                                        WASTE STREAM
                             DATA LISTING - SUBCATEGORIZATION FILE

--------------------------------------------- SUBCAT=PLASTICS ONLY ---------------------------------------------

   PLANT    O&GINF    O&GEFF    PHENOLINF    PHENOLEFF    NH3NINF    NH3NEFF    CHROMIUMINF    CHROMIUMEFF
   NUMBER   (PPM)     (PPM)     (PPM)        (PPM)        (PPM)      (PPM)      (PPM)          (PPM)
   -----    -----     -----     -----        -----        -----      -----      -----------    -----------

      2       .         4.00      .            .            .          .           .              0.50
      3     41.00      13.00     0.14         0.03         7.60      34.00        0.11            0.03
      4       .          .        .            .            .          .           .               .
      7       .          .        .            .            .          .           .               .
      9       .          .        .            .            .          .           .               .
     10       .          .        .            .            .          .           .               .
     11       .          .        .            .            .          .           .               .
     11       .          .        .            .            .          .           .               .
     12       .          .        .            .            .          .           .               .
     13       .          .        .            .            .          .           .               .
     14       .          .        .            .            .          .           .               .
     17       .          .        .            .            .        29.00         .               .
     17       .          .        .            .            .          .           .               .
     19       .          .        .           0.00          .         0.60         .               .
     25       .          .        .            .            .          .          1.46            0.01
     27       .          .        .            .            .          .           .               .
     29       .          .        .            .            .         0.80         .               .
     30       .          .        .            .            .          .           .               .
     33       .          .        .            .            .          .           .               .
     34       .          .        .            .           8.00       6.00         .               .
     35       .          .        .            .           0.00        .           .               .
     39       .          .        .            .            .          .           .               .
     44       .          .        .            .            .        35.00         .               .
     45       .          .        .           0.13         8.00       6.00         .              0.02
     46       .          .        .            .            .          .           .               .
     47       .          .        .            .            .          .           .               .
     47       .          .        .            .            .          .           .               .
     48       .          .        .            .            .          .           .               .
     52       .          .        .            .            .          .           .              0.02
     54       .          .        .            .            .          .          0.09            0.01
     56       .          .        .            .            .          .           .               .
     58       .          .        .            .            .          .           .               .
     62       .          .        .            .            .          .           .               .
     65       .          .        .            .            .          .           .               .
     67       .          .        .            .            .          .           .               .
     68       .          .        .            .            .          .           .               .
     70       .          .        .            .            .          .           .               .
     73       .          .        .            .            .          .           .               .
```

```
                                        WASTE STREAM
                           DATA LISTING - SUBCATEGORIZATION FILE

-------------------------------------- SUBCAT=PLASTICS ONLY --------------------------------------

PLANT     O&GINF   O&GEFF   PHENOLINF  PHENOLEFF  NH3NINF  NH3NEFF  CHROMIUMINF  CHROMIUMEFF
NUMBER    (PPM)    (PPM)    (PPM)      (PPM)      (PPM)    (PPM)    (PPM)        (PPM)
-----     -----    -----    -----      -----      -----    -----    -----------  -----------

   75       .        .        .          .          .        .        .            .
   77       .        .        .          .          .       2.00      .            .
   77       .        .        .          .          .        .        .            .
   77       .        .        .          .          .        .        .            .
   78       .        .        .          .          .        .        .            .
   79       .        .        .          .          .        .        .            .
   82       .        .        .          .          .        .        .            .
   82       .        .        .          .          .        .        .            .
   84       .        .        .          .          .        .        .            .
   84       .        .        .          .          .        .        .            .
   89       .        .        .          .        49.00    83.00      .            .
   90       .        .        .          .          .        .        .            .
   91       .        .        .          .          .        .        .            .
   91       .        .        .          .          .        .        .            .
   93       .        .        .          .          .       0.46      .            .
   96       .        .        .          .         2.00     .        .            .
  100       .        .       0.10       0.01       6.20     4.40      .            .
  100       .        .        .          .          .        .        .            .
  104       .       1.20     0.09       0.01       4.50     0.47      .            .
  104       .        .        .          .          .        .        .            .
  104       .        .        .          .          .        .        .            .
  104       .        .        .          .          .        .        .            .
  105       .        .        .         0.48        .       0.36      .            .
  106       .        .        .          .          .        .        .            .
  107       .        .        .          .          .        .        .            .
  109       .        .        .          .          .        .        .            .
  111       .        .        .          .          .        .        .            .
  119     23.00     2.00      .          .          .        .        .            .
  123       .        .        .          .          .        .        .            .
  124     23.00     6.00      .          .        30.00    20.00     0.20         0.30
  125       .        .       3.00       0.19        .        .        .            .
  126       .        .        .          .          .        .       2.00         0.05
  129       .        .        .          .          .        .        .            .
  131       .        .        .          .          .        .        .            .
  132       .        .        .          .          .        .        .            .
  140       .        .        .          .          .        .        .            .
  140       .        .        .          .          .        .        .            .
  146       .        .        .          .          .        .        .            .
```

WASTE STREAM
DATA LISTING - SUBCATEGORIZATION FILE

SUBCAT=PLASTICS ONLY

PLANT NUMBER	O&GINF (PPM)	O&GEFF (PPM)	PHENOLINF (PPM)	PHENOLEFF (PPM)	NH3NINF (PPM)	NH3NEFF (PPM)	CHROMIUMINF (PPM)	CHROMIUMEFF (PPM)
147	.	.	.	.	.	3.10	0.09	0.01
148	.	.	.	.	.	.	.	.
150	.	14.00	.	0.13	.	.	.	.
152	.	.	.	.	.	.	.	.
152	.	.	.	.	.	.	.	.
154	.	.	.	.	.	.	.	.
155	.	.	.	.	.	.	.	.
155	.	.	.	.	.	.	.	.
155	.	.	.	.	.	.	.	.
156	.	.	.	.	.	.	.	.
157	.	3.00	.	.	.	.	.	0.20
161	.	.	.	.	.	.	.	.
167	.	.	.	.	.	.	.	.
168	.	.	.	.	.	.	.	.
173	.	.	26.00	.	.	.	.	.
174	.	8.00	.	.	.	109.00	.	.
179	.	.	.	.	11.00	11.00	.	.
184	.	.	.	.	.	.	.	0.67
185	.	.	.	.	.	.	.	.
189	.	1.10	.	.	.	.	.	0.38
192	.	.	426.00	0.03	.	.	.	.
194	.	.	.	.	.	.	.	.
196	.	.	.	.	.	.	.	.
197	.	.	.	.	.	.	.	.
197	.	.	.	.	.	.	.	.
198	.	.	.	.	.	.	.	.
199	.	.	.	.	.	.	.	.
199	.	.	.	.	.	.	.	.
200	.	.	.	.	.	.	.	.
200	.	.	.	.	.	.	.	.
202	.	.	.	.	.	0.39	.	0.02
207	.	.	.	.	.	.	.	.
209	.	.	.	.	.	.	.	.
210	.	.	.	.	.	.	.	.
210	.	.	.	.	.	.	.	.
211	.	.	.	.	.	.	.	.
212	.	.	.	.	.	.	.	.
217	.	.	.	.	.	.	.	.

```
                                          WASTE STREAM
                             DATA LISTING - SUBCATEGORIZATION FILE

------------------------------------------ SUBCAT=PLASTICS ONLY -----------------------------------------

    PLANT    O&GINF    O&GEFF    PHENOLINF   PHENOLEFF   NH3NINF   NH3NEFF   CHROMIUMINF   CHROMIUMEFF
    NUMBER   (PPM)     (PPM)     (PPM)       (PPM)       (PPM)     (PPM)     (PPM)         (PPM)
    -----    -----     -----     -----       -----       -----     -----     -----------   -----------

     221       .         .         .           .           .         .            .             .
     221       .         .         .           .           .         .            .             .
     223       .         .         .           .           .         .            .             .
     224       .         .         .           .           .         .            .             .
     225       .         .         .           .           .         .            .             .
     227       .         .         .           .           .         .            .             .
     229    242.00     80.00       .           .           .         .            .             .
     232       .         .         .           .           .         .            .             .
     233       .        2.30       .           .           .         .            .           0.14
     237       .         .         .           .           .         .            .             .
     240       .         .         .           .           .         .            .             .
     241       .         .         .           .           .         .            .             .
     242       .         .         .           .           .         .            .             .
     243       .         .         .           .           .         .            .             .
     244       .         .         .           .           .         .            .             .
     244       .         .         .           .           .         .            .             .
     246       .         .         .           .           .         .            .             .
     249       .         .         .           .           .         .            .             .
     250       .         .         .           .           .         .            .             .
     251       .         .         .           .           .         .            .             .
     253       .         .         .           .           .         .            .             .
     254       .         .         .           .           .         .            .             .
     262       .         .        0.13        0.05       39.00     50.00          .             .
     265       .         .         .           .           .         .            .             .
     273       .        9.00       .           .           .         .            .             .
     277       .        4.10       .           .           .         .            .             .
     280       .         .         .           .           .         .            .             .
     282       .         .         .           .           .         .            .             .
     287       .        8.00       .          0.09         .         .            .             .
     288       .         .         .           .           .         .            .             .
     288       .         .         .           .           .         .            .             .
     289       .         .         .           .           .         .            .             .
```

WASTE STREAM
DATA LISTING - SUBCATEGORIZATION FILE

SUBCAT=NOT P, TYPE I&C, WATERUSE >.165 GAL/LB

PLANT NUMBER	O&GINF (PPM)	O&GEFF (PPM)	PHENOLINF (PPM)	PHENOLEFF (PPM)	NH3NINF (PPM)	NH3NEFF (PPM)	CHROMIUMINF (PPM)	CHROMIUMEFF (PPM)
20	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.
31	16.00	.	.	.	.	.	.	0.05
36	.	.	420.00	4.00	.	.	.	.
41	.	.	.	.	.	.	.	.
41	.	.	.	.	.	.	.	.
43	.	.	.	.	.	.	.	.
43	.	.	.	.	.	.	.	.
49	.	.	1.56	.	.	.	.	.
51	.	.	.	.	.	.	.	.
55	.	.	.	.	.	.	.	.
57	.	.	.	0.01	.	4.60	0.18	0.30
60	.	.	.	.	.	.	1.00	.
61	17.40	15.20	.	.	2.40	2.60	2.30	0.50
62	.	.	.	.	.	.	.	.
74	.	.	.	.	.	.	.	.
74	.	.	.	.	.	.	.	.
74	.	.	.	.	.	.	.	.
76	.	.	.	.	12.00	6.00	.	.
80	.	0.58	.	0.04	6.50	4.30	.	.
84	.	36.00	.	.	.	.	.	.
84	.	.	.	.	.	.	.	.
84	.	.	.	.	.	.	.	.
84	.	.	.	.	.	.	.	.
84	.	.	.	.	.	.	.	.
88	.	.	.	.	.	.	.	.
95	.	.	.	.	.	.	.	.
98	.	.	.	.	.	63.00	.	0.42
98	.	.	.	.	.	.	.	.
98	.	.	.	.	.	.	.	.
99	.	.	.	.	.	.	.	.
102	.	.	.	.	.	.	.	.
103	.	.	.	.	.	.	.	.
108	.	.	.	.	.	.	.	.
110	.	.	.	.	.	.	.	.
112	.	.	.	.	56.00	5.00	.	.
113	.	.	1.60	0.09	37.00	16.00	0.14	0.03
114	.	.	.	.	.	.	.	1.30

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                                            WASTE STREAM
                                DATA LISTING - SUBCATEGORIZATION FILE

------------------------------------- SUBCAT=NOT P, TYPE I&C, WATERUSE >.165 GAL/LB ----------------------------------------

    PLANT    O&GINF   O&GEFF   PHENOLINF   PHENOLEFF   NH3NINF   NH3NEFF   CHROMIUMINF   CHROMIUMEFF
    NUMBER   (PPM)    (PPM)    (PPM)       (PPM)       (PPM)     (PPM)     (PPM)         (PPM)
    -----    -----    -----    -----       -----       -----     -----     ----------    ----------

     127       .        .        18.00        3.60     303.00     80.00        .              .
     134       .        .          .           .          .         .          .              .
     134       .        .          .           .          .         .          .              .
     135       .        .          .           .          .         .          .              .
     135       .        .          .           .          .         .          .              .
     136       .        .          .           .          .         .          .              .
     136       .        .          .           .          .         .          .              .
     137       .        .          .           .          .         .          .              .
     137       .        .          .           .          .         .          .              .
     139       .        .          .           .          .         .          .              .
     139       .        .          .           .          .         .          .              .
     141       .        .          .           .          .         .          .              .
     141       .        .          .           .          .         .          .              .
     142       .        .          .           .          .         .          .              .
     142       .        .          .           .          .         .          .              .
     143       .        .          .           .          .         .          .              .
     143       .        .          .           .          .         .          .              .
     158       .        .          .           .          .       20.00        .              .
     160       .        .          .           .          .        7.80        .              .
     175       .        .          .           .          .         .          .              .
     176       .        .          .           .          .         .          .              .
     180       .        .          .           .          .         .          .              .
     180       .        .          .           .          .         .          .              .
     187       .        .          .           .       390.00    274.00        .              .
     190       .        .          .           .          .         .         0.10           0.10
     193       .        .         7.80        7.80      29.00     29.00        .              .
     195       .        .          .          0.01        .         .          .             0.09
     206       .        .          .           .          .         .          .             0.08
     215       .        .          .           .          .         .          .              .
     216       .        .          .           .          .         .          .              .
     216       .        .          .           .          .         .          .              .
     220       .        .        23.00        0.04        .         .          .              .
     222       .        .       173.00        0.60        .         .          .              .
     228       .        .          .           .          .       55.00        .              .
     234       .        .          .           .          .         .          .              .
     235       .        .          .           .          .         .          .              .
     236       .        .          .           .          .         .          .              .
     236       .        .          .           .          .         .          .              .
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                                         WASTE STREAM
                              DATA LISTING - SUBCATEGORIZATION FILE

---------------------------------------- SUBCAT=NOT P, TYPE I&C, WATERUSE >.165 GAL/LB ----------------------------------------

     PLANT     O&GINF    O&GEFF    PHENOLINF    PHENOLEFF    NH3NINF    NH3NEFF    CHROMIUMINF    CHROMIUMEFF
     NUMBER    (PPM)     (PPM)     (PPM)        (PPM)        (PPM)      (PPM)      (PPM)          (PPM)
     -----     -----     -----     -----        -----        -----      -----      -----------    -----------

      238        .         .          .            .            .          .            .              .
      248        .         .          .            .            .        42.00          .              .
      249        .        7.00        .            .            .         1.80          .              .
      257        .         .          .            .            .          .            .              .
      260        .         .          .            .            .          .            .              .
      272        .         .          .            .            .          .            .              .
      274        .         .          .            .            .          .            .              .
      276        .        9.00        .            .            .          .            .             0.30
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                                                WASTE STREAM
                                    DATA LISTING - SUBCATEGORIZATION FILE                                     32
---------------------------------- SUBCAT=NOT P, TYPE I&C, WATERUSE<=.165 GAL/LB ----------------------------------
PLANT      O&GINF    O&GEFF    PHENOLINF    PHENOLEFF    NH3NINF   NH3NEFF   CHROMIUMINF   CHROMIUMEFF
NUMBER     (PPM)     (PPM)     (PPM)        (PPM)        (PPM)     (PPM)     (PPM)         (PPM)
-----      -----     -----     -----        -----        -----     -----     -----------   -----------

   37         .         .          .            .           .          .          .              .
   38      539.00       .          .            .        292.00        .         1.85            .
   40         .         .          .            .           .          .          .              .
   42         .         .       747.00        36.00         .          .          .              .
   49         .         .          .           0.02         .         1.12        .             0.23
   50         .         .          .            .           .          .          .              .
   50         .         .          .            .           .          .          .              .
   51         .         .          .            .           .          .          .              .
   51         .         .          .            .           .          .         0.27            .
   63         .         .          .            .           .          .          .              .
   63         .        6.00        .            .          53.00     62.00       0.30           0.30
   63        0.75      0.75        .            .          3.20       3.20       0.14           0.14
   63         .         .          .            .           .          .          .              .
   81         .         .       148.00        16.00         .          .          .              .
   81         .         .          .            .           .          .          .              .
   81         .         .          .            .           .          .          .              .
   84         .         .          .            .           .          .          .              .
  138         .         .       445.00         1.40         .          .         0.39           0.18
  160         .         .          .            .           .          .          .              .
  163         .         .       705.00         0.21      380.00     146.00        .              .
  177         .         .          .            .           .          .          .              .
  177         .         .          .            .           .          .          .              .
  177         .         .          .            .           .          .          .              .
  188         .         .          .            .          6.40       5.60        .              .
  193         .         .          .            .           .          .          .              .
  218         .         .          .            .           .       125.00        .              .
  219         .         .          .            .           .          .          .              .
  239         .         .          .            .           .          .          .             0.02
  267         .         .          .            .           .          .          .              .
  268         .         .          .            .           .          .          .              .
  271         .         .        95.00         0.57         .         2.20        .              .
  276         .         .          .            .           .          .          .              .
  279         .         .       974.00          .         19.00       3.70        .              .
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                                         WASTE STREAM
                              DATA LISTING = SUBCATEGORIZATION FILE                                   33

-------------------------------------- SUBCAT=NOT P, TYPE I&NOT C --------------------------------------
 PLANT   O&GINF      O&GEFF      PHENOLINF   PHENOLEFF   NH3NINF     NH3NEFF     CHROMIUMINF CHROMIUMEFF
NUMBER   (PPM)       (PPM)       (PPM)       (PPM)       (PPM)       (PPM)       (PPM)       (PPM)
 -----   -----       -----       -----       -----       -----       -----       ----------- -----------

     1         .           .           .           .           .           .           .           .
    15         .           .           .           .           .           .           .           .
    16         .           .           .           .           .      782.00           .        0.83
    16         .           .           .           .           .           .           .           .
    22         .           .           .           .           .           .           .           .
    22         .           .           .           .           .           .           .           .
    26         .           .           .           .           .           .           .           .
    28         .           .           .           .        3.00        1.00           .           .
    32      570.00      112.00        2.50        0.02        1.80        1.40           .           .
    35         .           .           .           .           .           .           .           .
    53         .           .           .           .           .           .           .           .
    64         .           .           .           .           .           .           .           .
    69         .           .           .           .           .           .           .           .
    83         .           .           .           .           .           .           .           .
    85         .           .           .           .           .           .           .           .
    87         .           .           .           .       32.00        2.00           .           .
    87         .           .           .           .           .           .           .           .
    87         .           .           .           .           .           .           .           .
   117         .        1.00           .       14.00           .           .           .        0.07
   118         .           .           .           .           .           .           .           .
   128         .           .        2.00        0.02           .           .           .           .
   128         .           .           .           .           .           .           .           .
   130         .           .           .        0.08           .           .           .           .
   149         .           .           .           .      294.00           .        0.08           .
   159         .           .           .           .           .           .           .           .
   162         .           .           .           .           .           .           .           .
   164         .           .           .           .           .           .           .           .
   165         .           .           .           .           .           .           .           .
   170       17.00       11.00       18.00        0.17           .           .           .           .
   171         .       15.00           .        1.00           .       29.00           .           .
   178         .           .           .           .           .           .           .           .
   183         .           .           .           .           .           .        0.09        0.04
   183         .           .           .           .           .           .           .           .
   184         .           .           .           .           .           .           .        0.38
   191         .           .           .           .           .           .           .           .
   201         .           .           .           .           .           .           .           .
   203         .           .       10.70        0.79           .           .           .           .
   204         .           .           .           .           .           .           .           .
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                                              WASTE STREAM
                                    DATA LISTING = SUBCATEGORIZATION FILE

----------------------------------------------------- SUBCAT=NOT P, TYPE I&NOT C -----------------------------------------------------

      PLANT     O&GINF     O&GEFF    PHENOLINF    PHENOLEFF    NH3NINF    NH3NEFF    CHROMIUMINF    CHROMIUMEFF
      NUMBER    (PPM)      (PPM)     (PPM)        (PPM)        (PPM)      (PPM)      (PPM)          (PPM)
      -----     -----      -----     -----        -----        -----      -----      -----------    -----------

       213        .          .          .            .            .          .            .              .
       213        .          .          .            .            .          .            .              .
       230        .          .          .            .            .          .          0.50           0.30
       230        .          .          .            .            .          .            .              .
       256      418.00     23.00        .            .            .          .            .              .
       256        .          .          .            .            .          .            .              .
       259        .         1.00        .            .            .          .            .              .
       263        .          .          .            .            .         1.80          .              .
       264        .          .          .            .          233.00     80.00          .              .
       266        .          .          .            .            .          .            .              .
       269        .          .          .            .            .          .            .              .
       275        .          .         0.15         0.15         22.70      22.70        0.01           0.01
       281        .          .          .            .            .          .            .              .
       283        .          .          .            .            .          .            .              .
       284        .          .          .            .            .          .            .              .
       286        .          .          .            .            .          .            .              .
       286        .          .          .            .            .          .            .              .
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WASTE STREAM
DATA LISTING - SUBCATEGORIZATION FILE

-- SUBCAT=NOT P, NOT TYPE I --

PLANT NUMBER	O&GINF (PPM)	O&GEFF (PPM)	PHENOLINF (PPM)	PHENOLEFF (PPM)	NH3NINF (PPM)	NH3NEFF (PPM)	CHROMIUMINF (PPM)	CHROMIUMEFF (PPM)
5	.	0.42	.	.	.	.	.	0.02
6	.	46.00	2395.00	10.00	.	240.00	.	.
8	.	.	.	15.00	.	4.50	.	.
8	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	0.10
23	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.
59	.	3.00	.	0.12	.	.	0.00	0.00
66	.	.	.	0.10	.	.	.	0.10
71	.	.	.	.	.	.	.	.
72	.	.	.	.	.	.	.	.
86	.	1.60	.	.	.	.	.	.
92	.	.	.	.	.	.	.	0.05
92	.	.	.	.	.	.	.	.
94	.	.	4.00	0.20	65.60	64.10	0.21	0.02
97	.	.	.	.	.	.	.	.
101	.	.	.	.	.	.	.	.
101	.	.	.	.	.	.	.	.
115	.	.	.	.	.	.	.	.
116	.	.	.	.	.	.	.	.
120	.	.	.	.	8.80	3.70	.	.
121	.	.	120.00	0.20	.	.	.	.
121	.	.	.	.	.	.	.	.
122	420.00	1.00	.	.	.	.	.	0.03
129	.	.	.	.	.	.	.	.
131	.	.	.	.	.	.	.	.
133	.	.	.	.	.	.	.	.
144	.	.	.	.	.	.	.	.
145	.	.	.	0.65	.	.	.	0.29
151	.	.	.	0.02	.	2.20	.	0.23
151	.	.	.	.	.	.	.	.
153	.	.	.	0.30	.	.	.	2.00
166	.	.	.	.	.	.	.	.
169	.	.	.	.	.	.	.	.
172	286.00	.	23.00	.	.	.	0.74	.
181	.	.	.	.	80.00	.	.	.

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                                              WASTE STREAM
                                 DATA LISTING - SUBCATEGORIZATION FILE

------------------------------------------------ SUBCAT=NOT P, NOT TYPE I ------------------------------------------------

         PLANT     O&GINF    O&GEFF    PHENOLINF   PHENOLEFF   NH3NINF   NH3NEFF   CHROMIUMINF   CHROMIUMEFF
         NUMBER    (PPM)     (PPM)     (PPM)       (PPM)       (PPM)     (PPM)     (PPM)         (PPM)
         -----     -----     -----     -----       -----       -----     -----     -----------   -----------

          181        .         .         .           .           .         .           .             .
          182        .         .         .           .           .         .           .             .
          186        .         .         .         0.08          .         .           .             .
          205        .         .         .           .           .       1.70          .             .
          208      50.00     0.67      0.32        0.01        0.80      0.90        0.70         10.00
          214        .         .         .           .           .         .           .             .
          226        .         .         .           .           .         .           .             .
          231        .         .       88.00       2.20          .         .           .             .
          245        .         .         .           .           .         .           .             .
          247        .       0.77        .           .           .         .           .           0.08
          252        .         .         .           .        189.00       .           .             .
          252        .         .         .           .           .         .           .             .
          252        .         .         .           .       5331.00       .           .             .
          255        .       5.00        .         0.04          .         .           .           0.44
          258        .       1.46        .           .           .         .           .           0.05
          261        .         .         .           .           .         .           .             .
          270        .         .       8.30        0.44          .         .           .             .
          278        .         .         .           .           .         .           .             .
          285        .         .         .           .           .         .           .             .
          290        .         .         .           .           .         .           .             .
          291        .         .         .           .           .         .           .             .
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